The Creation and Use of an Analysis Capability Maturity Model® (ACMM)

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14. ABSTRACT

Reliable analyses to meet the needs of decision makers should be based on sound process. Capability Maturity Models® (CMMs) are being used in several intellectual endeavors; e.g., software engineering and systems engineering. This Analysis CMM (ACMM) has been created to provide guidance for developing and managing analysis processes, providing continuous process improvements, or appraising analysis organizations and their services. This report documents both the model, with its goals and practices, and an approach for assessing and improving an analysis organization's processes. If the ACMM goals are satisfied, there are potential benefits to the organization's process improvements and its ability to perform quality analyses, resulting in mission success for the analysis organization. Helping to establish and meet these goals is one of the main purposes for creating and using the ACMM.

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1. Introduction

A model is a simplified representation of the world that contains the essential elements of effective processes for a specific body of knowledge. CMM®s have been developed for organizations that use specialized bodies of knowledge to improve their internal process maturity, as well as to evaluate their processes. CMMs are being used in several intellectual endeavors to include software engineering, Software Acquisition (SA), and systems engineering. Four of these models have been integrated together into the Software Engineering Institute's (SEI's) Capability Maturity Model Integration (CMMI^SM). This model integrates Systems Engineering (SE), Software Engineering (SW), Integrated Product and Process Development (IPPD), and Supplier Sourcing (SS). Together these have the acronym CMMI-SE/SW/IPPD/SS.[1]

Our research has not found a CMM for the processes used by analysis organizations. We have created the Analysis Capability Maturity Model (ACMM) to provide a process framework for the body of knowledge related to analysis and operations research.* The CMM concepts were used in creation of this model, which is also founded on best practices from the Intelligence Community, DoD, academia, and industry.[2,5,7,8,10,15] Readers familiar with the CMMI will note that the Generic Goals and Practices were directly incorporated. Several process areas were adapted from the CMMI.

The ACMM identifies five levels of maturity. These levels correspond to the CMMI levels and are defined as follows:

1. The initial level, characterized by ad hoc processes, which can be chaotic.

2. The managed level, characterized by managed analysis processes, work products, and services for individual studies.

3. The defined level, characterized by standard analysis processes, work products, and services for the analysis organization.

4. The quantitative level, characterized by analysis tasks being managed quantitatively.

5. The optimizing level, with continuous improvement of analytic processes.

This analysis capability maturity model can be used as guidance for improving an analysis organization's processes and its ability to manage the development, acquisition, and maintenance of analysis products and services. The ACMM can also be used to help set process improvement objectives and priorities, improve processes, and provide guidance for ensuring stable, capable, and mature processes.

® CMM and Capabillity and Maturity Model are registered in the U.S. Patent and Trademark Office.
SM CMMI is a service mark of Carnegie-Mellon University.
* Morse and Kimball define Operations Research as: " . . .a scientific method of providing executive departments with a quantitative basis for decisions regarding operations under their control."

The ACMM does not specify the implementation necessary for any particular process area. Process development depends on the analysis organization's unique needs and is their responsibility. The ACMM does not establish goodness criteria for each process. The focus is on the existence of processes and their management. Development of effective analysis processes depends on implementing the generic practices associated with each specific practice. Generic practices provide institutionalization to ensure that the associated processes will be effective, repeatable, and lasting. The generic goals are characterized by four common features: those designed to produce an organizational commitment to perform the specific practice; those designed to ensure the ability to perform the specific practice; those directing implementation; and those to verify implementation.

If the ACMM goals are satisfied, there are potential benefits to the organization's ability to perform quality analyses, resulting in mission success for the analysis organization. Following well-defined, effective analysis processes promotes customer satisfaction and improves resource efficiency, analysis quality, and timeliness. At higher maturity levels, analyses will be delivered on schedule and budget. The ACMM is unique in that processes areas are provided to forecast and develop the necessary skills and capabilities for future studies.

The ACMM can be used as an appraisal instrument for exploratory appraisals, which are conducted to give management an assessment of the maturity of their analysis processes within the organization. It can also be used as a verification appraisal instrument to confirm an organization's maturity level following process improvement activities. An appraisal can be used to qualify or select an analysis organization to perform an important study.

An independent team, which did not include the authors of the ACMM, used an initial version of the ACMM to perform a confidential appraisal of a system engineering and analysis organization. The appraisal evaluated the analysis organization's capability to produce high-quality analysis products and services, focusing on current analysis work and comparing this work with the analysis needed to support the organization's mission. The appraisal recommended changes to the processes being used, identified tool shortfalls, and recommended development projects to close perceived analysis deficiencies. The team recommended minor changes to the ACMM, which have been incorporated in this document. Section 7, Analysis Capability Appraisal draws on the experience of this team.[8, 9]

The ACMM is recommended to analysis organizations interested in improving the reliability and quality of their studies. It is also recommended to the purchasers of operations research and system analysis who are often asked to take the conclusions and recommendations of a study on faith alone.

2. ACMM Creation

Creation of the ACMM began in order to facilitate an independent appraisal of analysis within a government program. The first step for the independent appraisal was to create a brief statement of work or charter for the effort. A search for a lead assessor was begun shortly thereafter. During this search, it became apparent that the charter needed elaboration, especially with regard to the appraisal of analysis processes.

A literature search revealed some interest in the processes to conduct some phases of analyses. However, a holistic treatment of analytic organizational process was not identified. The formal academic training for operations researchers apparently has a principal focus on optimization techniques. Problem formulation and metrics development are also taught.[5] It appears that the operations research community depends upon on-the-job training for study organization, execution, and management. The development and sustainment of analysis capabilities within the organization was a major concern for the appraisal, yet there was little how-to information on this topic. Several interesting analysis organization histories were found,[3,4] but these contained little about process.

Members of the lead-assessor search team had experience with Operations Research and exposure to Capability Maturity Models. Based on the Operations Research experience, a study model was constructed centered on the phases of analysis. This model was compared to the CMMI; significant intersection between the two models was observed. However, there were also significant differences. We decided to use CMM concepts. Appropriate process areas from the CMMI were combined with process areas created for unique analysis processes. The result was the Analysis Capability Maturity Model (ACMM).

Figure 2.1 provides an overview of the study process model used in developing the ACMM. Reviews with the customer are called for in several phases, which are opportunities for process iteration.

We decided to specify five levels of maturity for the ACMM that parallel those of other CMMs. The maturity levels identification serve as targets for process improvement for any analysis organization; as well as, managing expectations for a discovery appraisal. Within each process area are Specific Goals (SG) and Specific Practices (SP). For the initial appraisal, SG and SP for level three and below were evaluated. Levels four and five were created for model completeness.

Associated with each Specific Practice of the CMMI are Generic Goals (GG) and Generic Practices (GP). The GG and GP focus on institutionalizing that Specific Practice. Both the SP and the GP are needed. For the ACMM, the Generic Goals and Generic Practices were adopted from the CMMI.

Several of the SG and SP were also adopted from the CMMI. Others were adapted to the ACMM. In some cases, the concepts are the same but a different lexicon is used. Because the ACMM deviates substantially from the CMMI, responsibility for the model rests entirely with the authors.

Consumer/ Decision Makers

Decision Questions & Issues

Quantitative Basis For Decisions

Communications & Feedback

Establish & Maintain Analysis Capability

Analysis Formulation
1. Identify Issue
2. Identify Decision
3. Identify Stakeholders
4. Specify Level of Effort

Analysis Preparation
1. Develop Analysis Questions
2. Develop decision criteria
3. Identify incommensurables
4. Specify importance, ranking, of criteria
5. Develop measures
6. Bound the analysis
7. Develop alternatives
8. Develop ROMS of cost/ schedule
9. Review preparation with consumer

Analysis Planning
1. Develop & test algorithms to compute measures
2. Identify constraints
3. Estimate resources
4. Estimate schedule
5. Develop scenarios; alternate contexts for decisions
6. Test scenarios for sufficiency, detail, & issue illumination
7. Nominate data sources
8. Analysis Plan peer review
9. Review analysis planning with the consumer

Data Planning if Real World Data
1. Identify data sources
2. Plan for data collection
3. Develop sampling plan/ experiments design
4. Plan for data aggregation/ reduction
5. Plan for data certification
6. Estimate cost of data collection
7. Review cost & schedule with consumer

Data Planning if Expert Solicitation
1. Plan for data elicitation
2. Develop criteria for SMEs
3. Identify candidate SMEs
4. Evaluate candidate SME against criteria
5. Select SMEs
6. Estimate SME elicitation cost
7. Review cost & schedule with consumer

Data Planning if Model & Simulation
1. Develop selection criterion for M&S
2. Identify M&S alternatives
3. Select M&S
   If M&S development required
   a. Estimate development cost & schedule
   b. Review with appropriate stakeholders
   c. Modify existing M&S or create new
   d. Develop M&S
   e. Monitor development progress
4. Plan for accreditation of M&S
   a. Verification
   b. Validation
5. Design run plan (sensitivity)
6. Develop M&S execution cost & schedule
7. Review cost & schedule with consumer

Data Gathering
1. Data collection
2. Monitor & control data collection to assure adherence to plan
3. Certify data
4. Data delivery for analysis

Analysis Execution
1. Plot the data
2. Calculate measures

Analysis Resolution
1. Relate analysis to issues & questions
2. Relate measures to decision criteria
3. List incommensurables and other factors

Analysis Quality Assurance

Analysis Reporting
1. Final decision reporting
2. Lessons learned
3. Analysis details documentation
4. Analysis methods, data, & results archiving
   a. Taxonomy, data model, search to facilitate search
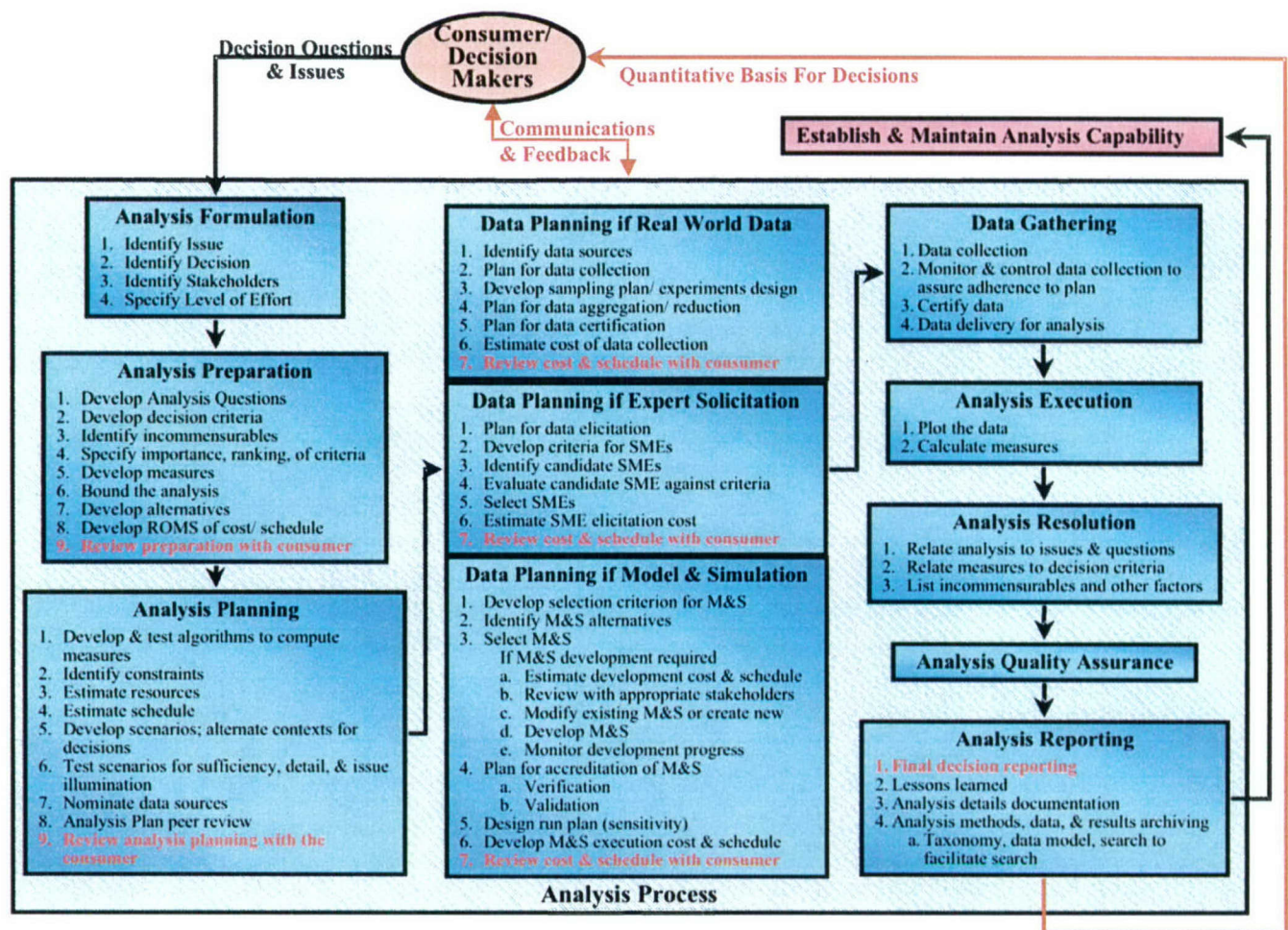
Analysis Process

Figure 2.1. Analysis process flow.

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3. Analysis/Study Best Practices

3.1   Good Analysis Principles

Through many years of practical experience, good analysis principles (including lessons learned) have been developed by various organizations that provide valuable guidance for any analysis organization's use to avoid repeating past problems. Among the major heuristics that good analysis organizations follow are:

- Use qualified expert judgment.

- Choose the right objectives.

- Test for sensitivity.

- Assess alternative designs (as important as analysis).

- Use interdisciplinary teams (required, not optional).

- Do not emphasize an optimization type of analysis for R&D questions.

- Compare multiple contingencies for complex or enterprise level questions.

- Relevant questions with partial answers are better than non-relevant questions with full answers.

- Cost estimates are essential for choosing among alternatives.

- Good ideas are worth a thousand evaluations.[10]

3.2   Successful Analysis/Study Processes

The following processes and practices have been developed for performing successful analyses and studies by following good analysis principles. These are a more detailed expansion and practical application of the ideas contained in the good analysis principles discussed above. (See Figure 2.1)

3.2.1   Formulate the Problem

Initial problem formulation is the responsibility of the customer of the study or analysis. However, the study organization is often called upon to assist the customer in defining the problem. In the initial iteration, it is critical to begin with an understanding of the real problem rather than a determination to apply readily available tools, scenarios, and data. Explicit problem formulation must precede construction of concepts for analysis or method selection. Consequently, problem formulation should focus on what needs to be done rather than on what can be done. Proper attention to problem formulation is essential to the overall efficiency and quality of the study. An understanding of the decisions to be supported by the analysis and the viewpoints of the various stakeholders helps to clarify the

study issues.[7] The following ordered steps provide a solid, proven process for proper formulation of an analysis or study:

- Prepare problem statement (definition of decision/analysis issues).

- Determine why the study is being done (understand how analysis influences decisions).

- Work with the customer to decide on customer's resource investment (level of effort). This is what the customer is willing to pay to have quantitative support for his decision.

- Identify all of the stakeholders.

- Obtain commitment to the analysis issues.

- Manage analysis issue changes (iterative process).

- Maintain consistency between analysis results and issues (iterative process).

3.2.2   Prepare for Analysis

3.2.2.1   Identify Analysis Decision Factors

Identifying and understanding the factors that affect the decision process is vital for planning and implementing analyses. Begin with the end in mind. The following factors ensure that a comprehensive set of problem solution alternatives are analyzed and that an exit strategy has been defined when considering alternatives so that excess effort is not applied to the trade space:[2]

- Develop analysis questions.

- Develop decision alternatives and criteria.

- Identify any constraints and assumptions.

- Develop decision criteria and rank according to importance.

- Identify incommensurables. Often in a decision, the incommensurables are more significant that the quantitative factors.

- Bound the analysis. A tight focus on the really important elements of the analysis is needed to avoid paralysis by analysis. A bounded study is essential to estimate costs and schedule. As the study progresses, bounding the analysis initially will avoid creep.

- Establish rules or standards for alternatives.

- Develop and evaluate alternatives.

- Select an alternative—this implies that those specific resources are no longer available for other purposes

3.2.2.2 Develop Quantitative Measures Using Quantitative Criteria

Quantitative criteria must be applied when developing measures to assess mission effectiveness or functional performance. These criteria must be sensitive to the independent factors of the analysis and are explored using sensitivity analyses. These measures will also be the means for arriving at quantitative results that can be used as the basis for decision. The following measures help to determine when the analyses are successful:

- Measures of Effectiveness (MoEs)—mission performance indicators

- Measure of Performance (MoPs)—functional performance indicators

- Measures of Uncertainty (MoU)—Uncertainty is permissible, but the uncertainty degree and sources must be documented. Inserting odds ratios or numerical probability ranges to clarify key points should be standard practice.[6]

- Measures of Cost—Cost can be measured in a number of ways: acquisition cost, life-cycle cost, or opportunity cost. A consistent cost measure is needed in order to weigh cost against other measures.

- Provide means for weighing cost versus performance.

- Develop Rough Orders of Magnitude (ROMs) of cost/schedule.

3.2.3 Prepare an Analysis Plan

Most analysis efforts are complex in nature and must be monitored and controlled against a well thought out plan of action. Technical analysis capability as well as consideration of limited resources, tight budgets, tough schedules, and associated risk management must be accounted for in the plan. Adequate time must be allocated for collecting data, building models, developing algorithms, and preparing operations scenarios. The following activities can help in the development of a good analysis plan:

- Specify measures.

- Abstract the important features of the decision or problem.

- Establish schedule for study results.

- Identify or develop algorithms for computing the measures.

- Specify the data necessary for the algorithm.

- Generate alternatives, justify why some alternatives are deemed less likely, and express the likelihood that events may not turn out as expected.

- Prepare scenarios (controlled situations) to explore the trade space—do not use to try to define requirements. Scenarios provide a framework for exploring the implications of decisions.

The products of these activities should be included in the plan.

3.2.4 Plan for Data

There are three likely sources for analysis data: the real world, either data that is gathered from operations, exercises, or experiments; models and simulations; and subject matter experts. Each of these data sources needs to be identified and qualified in some fashion. The following activities should be used for the development of the data plan:

- Identify data sources.

- Plan for data collection/elicitation.

- Develop data sampling plan.

- If using SMEs, develop selection criteria and identify candidates.

- Evaluate SME candidates against criteria and make selections.

- If using models and simulations, develop selection criteria.

- Identify appropriate models and simulations.

- Identify Modeling and Simulation (M&S) alternatives and make selection.

- Identify required M&S development requirements.

- If development required, estimate cost and schedule.

- Review with stakeholders.

- Modify existing M&S or create new.

- Monitor development progress.

- Design run plan (sensitivity).

- Plan for data aggregation/reduction.

- Plan for data certification/M&S accreditation.

- Estimate cost and schedule of data planning.

The data plan should be reviewed for completeness. There is nothing more frustrating than to discover missing elements that are essential to the analysis. It is good practice to conduct a rehearsal if data is to be gathered in the real world. For models and simulations, a small pilot may reveal any flaws in the data planning.

3.2.5 Gather Data

After all the planning and preparation is completed, the data is gathered and delivered to the analyst for processing into the study products. The data collection must be monitored and controlled to

assure adherence to the data plan. The data must be certified to assure credible analysis results and then delivered to the analysts in a timely manner to maintain schedules.

3.2.6 Execute the Analysis Plan

Once the plan has been successfully developed and approved by the decision makers, it must be executed according to the activities, resources, and schedules in the plan. It becomes the living document to monitor and control progress of the analysis effort. When decision needs change, as they frequently do, the plan must be flexible enough to allow modification without major interruption to the process. The following activities are vital for effective management and implementation of planning and for producing quality analyses:

- Monitor plan execution.

- Identify data shortfalls and fill the gaps where data is missing.

- Monitor progress in M&S modification.

- Test the scenarios and algorithms. Assess the impact of the proposed capability on the problem situation.

- Document and communicate the results.

3.2.6.1 Analysis Resolution & QA

The data produced by the analysis needs to be interpreted to find meaning. In addition, peer review and critical examination is needed to avoid errors. Providing and maintaining issues and analysis results traceability, relating measures to decision criteria, and listing incommensurables and other factors will guide analysis resolution.

3.2.6.2 Report Analysis Results

The presentation of analytical results may be as important as the analysis itself. The results must be framed in terms that are easily understood by the executive. If they do not understand, they will not use the analysis in making the decision. It is also important to capture the essential elements of the analysis to facilitate review and reuse of methods, data, and algorithms.

Often an analysis will age for a considerable period of time. It is then resurrected. Good documentation and archiving will assure that the analysis can be explained and extended. The following should be practiced routinely during and at the conclusion of every analysis:

- Maintain consistency between analysis results and issues (iterative process).

- Capture and document lessons learned.

- Document analysis details.

- Archive analysis methods, data, and results.

4. Analytic Management Best Practices

Executives need not be expert in quantitative methods, but they cannot leave the field to experts. They must know when quantitative methods are valuable and when they are reliable. They must have the confidence to accept or override the recommendations of the operations research staff as the situation demands and must appreciate the nature and role of corporate systems analysis. The manager needs to understand how to structure a large or complex task so that it can be solved.[15]

4.1   Management Environment

Managers help create an organizational environment where analytical excellence flourishes. This environment includes using practices that fall into three general categories:

4.1.1   Research

Management supports research to understand the cognitive processes used in making analysis judgments, but needs to understand how thinking skills are involved in analysis, how to test analysts for these skills, how to train analysts to improve these skills, and how cognitive limitations affect analysis and how to minimize their impact. Simple tools and techniques help prevent avoidable error.

4.1.2   Training

Managers should make sure that analysts' training is focused on organizational procedures, writing style, and methodological techniques. The training should be devoted to thinking and reasoning processes involved in making judgments, and to trade tools available to alleviate known analysis cognitive problems.

4.1.3   Exposure to Alternative Mind-Sets

Management needs to ensure that well-reasoned competing views have the opportunity to surface within the analysis community. Analysts need to enjoy a sense of security so that new ideas may be expressed with minimal fear of criticism for deviating from established orthodoxy. Management can promote activities that confront analysts with alternative perspectives, e.g., consultation with outside experts, analytical debates, competitive analysis, devil's advocates, gaming, and interdisciplinary brainstorming. Analysts from other areas who are not specialists in the subject matter should also be used.

4.2   Analysis Capability Improvement Management

Management should mandate a systematic analytical process. The following steps define the process used to develop, manage, and control analysis capability improvements:

- Identify and understand current and future analyses problems.
- Define the objectives of expected analyses
    - To understand how analysis processes are performed
    - To improve the analysis process—both technical and managerial
- Collect and assess current analysis capability data (establish baseline)
    - Determine what analyses the organization is doing.
    - Collect and review current analysis capability data (characterize job).
    - Identify and assess current organization analysis processes/tools.
    - Interview analysts and stakeholders to determine processes usage.
- Assess future organization analysis capabilities needs
    - Determine what analyses the organization should be doing.
    - Interview analysts, users, and stakeholders to identify future needs.
    - Prepare a periodic forecast concerning likely areas for analysis to develop resource plans, analysis capability development analysis, and background materials and technologies to facilitate rapid response when a specific issue, topic, or analysis question is posed.
- Compare baseline capabilities and future analysis needs
    - Use the SEI CMMI concepts (or ACMM) as a model for processes/goals/practices.
    - Identify and assess areas where analysis shortfalls exist.
    - Provide recommendations to fill the gaps (tools, processes, training, etc.).
- Develop and implement plans to update organization analysis capabilities as required
    - Establish selection criteria (cost, schedule, performance).
    - Prioritize and perform make or buy decisions.[14]

5. Analysis Capability Maturity Model (ACMM)

The ACMM is a process framework with a number of elements: Specific Goals, Specific Practices, Generic Goals, Generic Practices, and maturity levels. Each Specific Goal has one or more Specific Practices. For the ACMM, the Specific Goals are aggregated into four process areas: Analysis Implementation, Analysis Management, Analytic Process Management, and Analysis Sustainment. These elements are represented in Figure 5.1.

Associated with each Specific Practice are Generic Goals appropriate to the maturity level. The Generic Goals are general planning, control, implementation, and sustainment goals for the Specific Practices. Generic Goals are common for all Specific Practices at the same maturity level. Each Generic Goal has one or more Generic Practices.
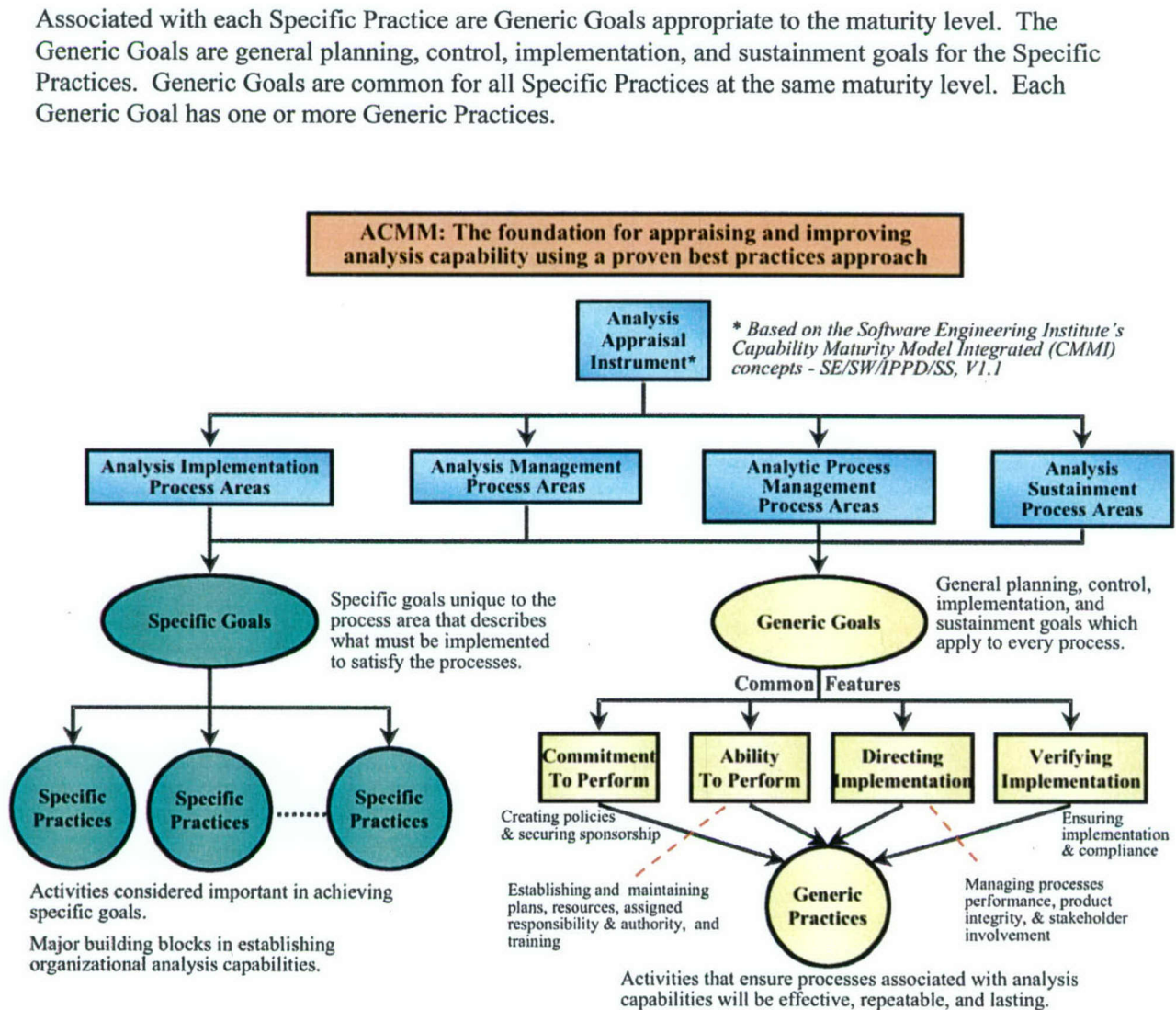

Figure 5.1. ACMM overview.

5.1   Maturity Levels

The ACMM identifies five maturity levels that correspond to the CMMI levels defined as follows:

1. Ad hoc processes characterize the initial level, which can be chaotic. The organization usually does not provide a stable environment. Successes in these organizations depend on the competence and heroics of the personnel in the organization and not on the use of proven processes. Chaotic organizations can produce quality studies, but they frequently exceed budget and schedule.

2. Managed analysis processes, work products, and services for individual studies characterize the managed level. The organization has achieved all the specific and generic goals of the level-two process areas. This means that a study is planned, and management has insight into the status of work products and services at defined points during execution. However, there are insufficient processes to qualify the models and simulations, data, and experts used in the study. The organization is very focused only on the work at hand and getting the job out the door. Estimation of schedule and resources is ad hoc with a risk to study success.

3. Standard analysis processes, work products, and services for the analysis organization characterize the defined level. The organization has achieved all the specific and generic goals of the level-two and -three process areas. This means that there is a greater focus on the quality of the inputs to an analysis, on the work products created, and on the final study report. Risk is managed. Standard organizational processes are available and used to perform each study. The organization plans for the capabilities for the current study. The organization also forecasts future studies and plans to acquire the capabilities to perform them.

4. The quantitative level is characterized by analysis tasks being managed quantitatively. The organization has achieved all the specific goals of level-two, -three, and -four process areas and the generic goals of levels two and three. Quantitative objectives for quality and process performance are established and used as criteria in managing processes. Quality and process performance are understood in statistical terms and are managed throughout the life of the processes. Quality and process performance measures are incorporated into the organization's measurement repository to support fact-based decisions.

5. Continuous improvements of analytic processes characterize the optimizing level. The organization has achieved all the specific goals of level-two, -three, -four, and -five process areas and the generic goals of levels two and three. Processes are improved based on the quantitative understanding of the common causes of variation. The focus of a level-five organization is on incremental and innovative improvements.

In the following sections, the standard CMMI maturity levels 2 through 5 of each process is listed in parenthesis following the title of the process.

5.2 Specific Goals and Practices

The Specific Goals (SG) and Specific Practices (SP) are aggregated into four process areas: Analysis Implementation, Analysis Management, Analytic Process Management, and Analysis Sustainment. This aggregation is somewhat arbitrary and is used as a convenient taxonomy.

5.2.1 Analysis Implementation Process Area

The analysis implementation process area consists of related processes performed to achieve an appropriate, repeatable, reliable, and objective quantitative analysis. Six of these process areas focus on the processes used to actually perform the analysis: analysis formulation, analysis and data planning, analysis execution, analysis resolution, and analysis reporting. The remaining three are concerned with the quality of the inputs to the analysis and include: work product confirmation, model and simulation corroboration, and qualification of subject matter experts.

Analysis Formulation (2) Analysis Formulation identifies the issue to be analyzed and the decision to be supported, including the decision maker. The time frame for the analysis is specified. Analysis Formulation also identifies stakeholders to the decision and participants in the analysis. An initial commitment to a level of effort to be expended is identified. The owner of the issue, often the decision maker, who may be assisted by an analysis organization, conducts Analysis Formulation. The Analysis Formulation product is frequently called the Terms of Reference (TOR) for the analysis.

SG 1 Manage Analysis Issues—Issues are identified and managed and inconsistencies with decisions and analytic products are identified.

SP 1.1-1	Obtain an understanding of analysis issues.
SP 1.2-1	Obtain an understanding of the decisions influenced by the analysis.
SP 1.3-1	Develop alternative decisions and the decision criteria.*
SP 1.4-1	Obtain commitment to the issues to be analyzed.
SP 1.5-1	Manage changes in analysis issues.
SP 1.6-1	Maintain bi-directional traceability of issues and analysis products.
SP 1.7-1	Identify inconsistencies between analysis products and issues.

Analysis and Data Planning (2) Analysis and Data Planning establishes and maintains plans that define analysis and data collection activities to evaluate possible decisions using a formal evaluation that compares alternatives using quantified criteria. Once the analysis question is understood, study archives, lessons learned, and external literature are surveyed to establish an analysis baseline for planning. Efficient planning avoids plowing old ground and builds on existing bodies of knowledge. An analysis plan designs and develops the algorithms and supporting data to answer the analysis issues. This plan is established and maintained as the basis for managing the analysis.

SG 1 Establish Estimates—Establish and maintain analysis planning parameter estimates.

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* Adapted from CMMI, Technical Solution to identify alternative decisions

SP 1.1-1	Determine an analysis baseline founded on study archives, lessons learned, and external literature.
SP 1.2-1	Estimate the scope of the analysis.
SP 1.3-1	Establish estimates of work products and task attributes.
SP 1.4-1	Define analysis life cycle.
SP 1.5-1	Determine effort and cost estimates.

SG 2 Develop an Analysis Plan—Establish and maintain an analysis plan as the basis for managing the analysis.

SP 2.1-1	Establish guidelines for analysis.[*]
SP 2.2-1	Establish evaluation criteria.[†]
SP 2.3-1	Select Measures of Merit.[‡]
SP 2.4-1	Identify and develop alternative analysis approaches and selection criteria.[§]
SP 2.5-1	Evaluate alternative approaches to the analysis.[**]
SP 2.6-1	Select analysis approach.[††]
SP 2.7-1	Develop detailed options for decision and selection criteria.[‡‡]
SP 2.8-1	Evolve operational concepts and scenarios (context in which options are evaluated).[§§]
SP 2.9-1	Identify analysis risks.
SP 2.10-1	Plan for analysis resources.
SP 2.11-1	Establish the analysis plan.
SP 2.12-1	Determine data needs.[***]
SP 2.13-1	Establish a technical data package.[†††]

SG 3 Develop a Data Plan—Establish and maintain a data plan as the basis for managing the data called for in the analysis plan.

SP 3.1-1	Plan for data management.
SP 3.2-1	Plan for data certification.
SP 3.3-1	Establish data descriptions.[‡‡‡]
SP 3.4-1	Analyze potential data sources.[§§§]
SP 3.5-1	Evaluate and determine data sources.
SP 3.6-1	Perform make, acquire, or reuse data analyses.
SP 3.7-1	Establish the data plan.

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[*] Source CMMI, DAR
[†] Source CMMI, DAR
[‡] Source CMMI, DAR
[§] Source CMMI, Technical Solution
[**] Source CMMI, DAR
[††] Source CMMI, DAR
[‡‡] Source CMMI, Technical Solution
[§§] Source CMMI, Technical Solution
[***] Source CMMI, Technical Solution
[†††] Source CMMI, Technical Solution
[‡‡‡] Source CMMI, Technical Solution
[§§§] M&S, real world data, elicitation

SG 4 Integrate the Plans.[*]

    SP 4.1-1   Integrate the analysis and data plans.[†]
    SP 4.2-1   Plan for needed knowledge and skills.
    SP 4.3-1   Plan stakeholder involvement.
    SP 4.4-1   Develop analysis and data support documentation.[‡]
    SP 4.5-1   Establish the budget and schedule.

SG 5 Obtain Commitment to the Plan —Establish and maintain analysis plan commitments.

    SP 5.1-1   Review plans that affect the analysis.
    SP 5.2-1   Reconcile work and resource levels.
    SP 5.3-1   Obtain plan commitment .

Analysis Execution (2) Analysis Execution gathers the data, performs the analysis using the data, and ensures that analytic products are accurate and correct.

SG 1 Prepare for Analysis Execution.

    SP 1.1-1   Review plans for completeness.
    SP 1.2-1   Establish the analysis environment.
    SP 1.3-1   Determine data gathering or generation sequence.
    SP 1.4-1   Establish data formats and file structures.

SG 2 Data Gathering and Certification.

    SP 2.1.1   Collect the data using the data plan.
    SP 2.2-1   Monitor selected data gathering processes.
    SP 2.3-1   Evaluate selected data .
    SP 2.4-1   Revise the data supplier agreement or relationships.
    SP 2.5-1   Certify data.

SG 3 Analyze the Data Product Measures of Merit.

    SP 3.1-1   Confirm readiness of data components for aggregation.
    SP 3.2-1   Aggregate data into Measures of Merit.
    SP 3.3-1   Package analytic work products.

Analysis Reporting (2) Analysis Reporting reports the analytic results, documents the analytic work products, and archives the analytic products.

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[*] Source CMMI, Technical Solution
[†] Source CMMI, Technical Solution
[‡] Source CMMI, Technical Solution

SG 1 Document analysis work products.

    SP 1.1-1   Document analysis details.
    SP 1.2-1   List incommensurables and other factors.

SG 2 Analysis Reporting.

    SP 2.1-1   Report final analysis interpretation.

SG 3 Analysis Archiving.

    SP 3.1-1   Archive analysis methods, data, results, and lessons learned.[*]

Analysis Resolution (3) Analysis Resolution gives meaning to the analytic work products, relates the analysis back to the business or operation problem, and identifies factors outside the scope of the analysis.

SG 1 Interpret Analysis Work Products.

    SP 1.1-1   Relate analysis to the issues and questions.
    SP 1.2-1   Relate measures to the decision criteria.

SG 2 Identify significant factors outside the scope of the analysis.

    SP 2.1-1   List incommensurables and other factors.

Work Product Confirmation (3) Work Product Confirmation ensures that selected work products[†] meet their specified needs.

SG 1 Prepare for Confirmation.

    SP 1.1-1   Select work products for confirmation.
    SP 1.2-1   Establish the confirmation environment.
    SP 1.3-1   Establish confirmation procedures and criteria.

SG 2 Perform Peer Reviews.

    SP 2.1-1   Prepare for peer reviews.
    SP 2.2-1   Conduct peer reviews.
    SP 2.3-1   Analyze peer review data.

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[*] Good practice to have a taxonomy, data model, for analysis to facilitate search.
[†] Applies to work products and M&S.

SG 3 Confirm Selected Work Products.

    SP 3.1-1   Perform confirmation.
    SP 3.2-1   Analyze confirmation results and identify corrective actions.

Model or Simulation Corroboration (3) Corroboration demonstrates that a model or simulation corresponds to the real world with sufficient fidelity for the intended analyses. Models and simulations are used for analysis when it may not be feasible or affordable to perform statistically significant experiments in the real world. However, there are usually portions of the model that can be compared to real-world data. Corroboration selects those elements of the model or simulation for comparison to the real-world data. Conclusions from corroboration are used to support models and simulations accreditation.

SG 1 Prepare for Corroboration—Preparation for corroboration is conducted.

    SP 1.1-1   Select model or simulation for corroboration.
    SP 1.2-1   Select features of the model or simulation for corroboration.
    SP 1.3-1   Identify the real-world data to be used for comparison.
    SP 1.4-1   Establish the corroboration environment.
    SP 1.5-1   Establish corroboration procedures and criteria.

SG 2 Corroborate the Model or Simulation—The models or simulations are corroborated to ensure that they are true to the real world.

    SP 2.1-1   Generate synthetic data for corroboration using models or simulations.
    SP 2.2-1   Compare synthetic data to the real-world data.
    SP 2.3-1   Analyze the agreement between the synthetic and real-world datasets.

Subject Matter Expert Qualification (3) Subject Matter Expert (SME) Qualification selects individuals with the requisite knowledge areas to opine on selected issues of an analysis. SMEs are often used to create importance rankings for decision criteria.

SG 1 Develop Qualifications—Needed qualifications for SME(s) are developed.

    SP 1.1-1   Select analysis issue for the SMEs.
    SP 1.2-1   Identify knowledge or expertise needed for the analysis issue.
    SP 1.3-1   Establish desired credentials for the SME.

SG 2 Select the SME—The desired credentials are compared to individual candidates.

    SP 2.1-1   Generate prospective SME pool.
    SP 2.2-1   Elicit SME candidates' credentials.
    SP 2.3-1   Compare SME candidates' credentials with the desired credentials.
    SP 2.4-1   Select SME from the candidate pool.

5.2.2   Analysis Management Process Areas

The analysis management process area consists of related processes performed to manage analyses. One specific process deals with understanding progress against the plan. Another deals with risk management. The use of defined processes, organization, and operation of the internal study team are the subjects of a process area. Two specific processes—analysis provider agreement and management of external stakeholder involvement—deal with management external to the organization. This process area contains a level-four process area: quantitative analysis management.

Analysis Monitoring and Control (2) Analysis Monitoring and Control provides an understanding of the analysis's progress so that appropriate corrective actions can be taken when the analysis's performance deviates significantly from the plan.

SG 1 Monitor Analysis Against Plan—Actual performance and progress of the analysis are monitored against the analysis plan.

SP 1.1-1	Monitor analysis planning parameters.
SP 1.2-1	Monitor commitments.
SP 1.3-1	Monitor analysis risks.
SP 1.4-1	Monitor data management.
SP 1.5-1	Monitor stakeholder involvement.
SP 1.6-1	Conduct progress reviews.
SP 1.7-1	Conduct milestone reviews.

SG 2 Manage Corrective Action to Closure—Corrective action is managed to closure when the analysis's performance or results deviate significantly from the plan.

SP 2.1-1	Analyze issues.
SP 2.2-1	Take corrective action.
SP 2.3-1	Manage corrective action.

Analysis Provider Agreement (2) Analysis Provider Agreement manages analyses received from providers, for which there exists a formal agreement.

SG 1 Establish Provider Agreements—Agreements with the providers are established and maintained.

SP 1.1-1	Specify analysis to be provided.
SP 1.2-1	Determine potential providers.
SP 1.3-1	Select providers.
SP 1.4-1	Establish provider agreements.

SG 2 Satisfy Provider Agreements—Agreements with the providers are satisfied by both the analysis and the provider.

SP 2.1-1	Review products.

SP 2.2-1   Execute the provider agreement.
SP 2.3-1   Accept the provider product.
SP 2.4-1   Transition products.

Management of External Stakeholder Involvement (3) Management of External Stakeholder involvement establishes and manages the analysis and the relevant stakeholders involvement according to an integrated and defined process that is tailored from the organization's set of standard processes.

SG 1 Coordinate and Collaborate with Relevant Stakeholders.

SP 1.1-1   Manage stakeholder involvement.
SP 1.2-1   Manage dependencies.
SP 1.3-1   Resolve coordination issues.

SG 2 Develop the shared vision for External Stakeholder Involvement management.

SP 2.1-1   Define analysis's shared-vision context.
SP 2.2-1   Establish the analysis's shared vision.

SG 3 Organize Integrated Teams for Analysis.

SP 3.1-1   Determine the integrated team structure for the analysis.
SP 3.2-1   Develop a preliminary distribution of analysis activities to external stakeholders.
SP 3.3.1   Identify external stakeholder data sources.
SP 3.4-1   Establish integrated teams.

Risk Management (3) Risk Management identifies potential problems before they occur so that risk-handling activities may be planned and invoked as needed across the life of the product or analysis to mitigate adverse impacts on achieving objectives.

SG 1 Prepare for Risk Management [PA148.IG101].

SP 1.1-1   Determine risk sources and categories.
SP 1.2-1   Define risk parameters.
SP 1.3-1   Establish a risk management strategy.

SG 2 Identify and Analyze Risks.

SP 2.1-1   Identify risks.
SP 2.2-1   Evaluate, categorize, and prioritize risks.

SG 3 Mitigate Risks.

SP 3.1-1   Develop risk mitigation plans.
SP 3.2-1   Implement risk mitigation plans.

Management of the Internal Analysis Team (3) The Internal Analysis Team management forms and sustains an internal analysis team for analysis products development. Internal analysis team management also covers a shared-vision establishment for the analysis and a team structure for integrated teams that will carry out the analysis objectives.

SG 1 Use the Analysis Defined Process.

SP 1.1-1   Establish the defined process for the analysis effort.
SP 1.2-1   Use organizational process assets for planning analysis activities.
SP 1.3-1   Integrate plans.
SP 1.4-1   Manage the analysis using the integrated plans.
SP 1.5-1   Contribute to the organizational process assets.

SG 2 Establish Team Composition.

SP 2.1-1   Identify team tasks.
SP 2.2-1   Identify needed knowledge and skills.
SP 2.3-1   Assign appropriate team members.

SG 3 Govern Team Operation.

SP 3.1-1   Establish a shared vision.
SP 3.2-1   Establish a team charter.
SP 3.3-1   Define roles and responsibilities.
SP 3.4-1   Establish operating procedures.
SP 3.5-1   Collaborate among interfacing teams.

Quantitative Analysis Management (4) The Quantitative Analysis Management process area quantitatively manages the Analysis's defined process to achieve the Analysis's established quality and process-performance objectives.

SG 1   Quantitatively Manage the Analysis.

SP 1.1-1   Establish the analysis's objectives.
SP 1.2-1   Compose the defined process.
SP 1.3-1   Select the sub-processes that will be statistically managed.
SP 1.4-1   Manage analysis performance.

SG 2   Statistically Manage Sub process Performance.

SP 2.1-1   Select measures and analytic techniques.

SP 2.2-1	Apply statistical methods to understand variation.
SP 2.3-1	Monitor performance of the selected sub-processes.
SP 2.4-1	Record statistical management data.

5.2.3 Analytic Process Management Process Area

The Analytic Process Management Process Area consists of related processes performed to achieve a set of process management goals. The five process areas within this category are for the organization and are level three or higher. All of these—Organizational Process Focus, Organizational Process Definition, Organizational Training, Organizational Process Improvement, and Organizational Innovation and Deployment—focus on establishing, maintaining, and improving organizational processes.

Organizational Process Focus (3) The Organizational Process Focus plans and implements organizational process improvement based on a thorough understanding of the current strengths and weaknesses of the organization's processes and process assets.

SG 1   Determine Process-Improvement Opportunities.

SP 1.1-1	Establish organizational process needs.
SP 1.2-1	Appraise the organization's processes.
SP 1.3-1	Identify the organization's process improvements.

SG 2   Plan and Implement Process-Improvement Activities.

SP 2.1-1	Establish process action plans.
SP 2.2-1	Implement process action plans.
SP 2.3-1	Deploy organizational process assets.
SP 2.4-1	Incorporate process-related experiences into the organizational process assets.

Organizational Process Definition (3) Organizational Process Definition establishes and maintains a usable set of organizational process assets.

SG 1   Establish Organizational Process Assets.

SP 1.1-1	Establish standard processes.
SP 1.2-1	Establish life-cycle model descriptions.
SP 1.3-1	Establish tailoring criteria and guidelines.
SP 1.4-1	Establish the organization's measurement repository.
SP 1.5-1	Establish the organization's process asset library.

Organizational Training (3) Organizational Training develops the skills and knowledge of people so they can perform their roles effectively and efficiently.

SG 1   Establish an Organizational Training Capability.

SP 1.1-1   Establish the strategic training needs.
SP 1.2-1   Determine which training needs are the organization's responsibility.
SP 1.3-1   Establish an organizational training tactical plan.
SP 1.4-1   Establish training capability.

SG 2   Provide Necessary Training.

SP 2.1-1   Deliver training.
SP 2.2-1   Establish training records.
SP 2.3-1   Assess training effectiveness.

Organizational Process Performance (4) Organizational Process Performance establishes and maintains a quantitative understanding of the performance of the organization's set of standard processes in support of quality and process-performance objectives, and provides the process performance data, baselines, and models to quantitatively manage the organization's analyses.

SG 1   Establish Performance Baselines and Models.

SP 1.1-1   Select processes.
SP 1.2-1   Establish process performance measures.
SP 1.3-1   Establish quality and process-performance objectives.
SP 1.4-1   Establish process performance baselines.
SP 1.5-1   Establish process performance models.

Organizational Innovation and Deployment (5) The Organizational Innovation and Deployment process area selects and deploys incremental and innovative improvements that measurably improve the organization's processes and technologies. The improvements support the organization's quality and process-performance objectives as derived from the organization's business objectives.

SG 1   Select Improvements.

SP 1.1-1   Collect and analyze improvement proposals.
SP 1.2-1   Identify and analyze innovations.
SP 1.3-1   Pilot improvements.
SP 1.4-1   Select improvements for deployment.

SG 2   Deploy Improvements.

SP 2.1-1   Plan the deployment.
SP 2.2-1   Manage the deployment.
SP 2.3-1   Measure improvement effects.

5.2.4   Analysis Sustainment Process Area

The Analysis Sustainment Process Area contains processes that are used by processes in other areas. These processes are performed to sustain analysis capability, measure analytic performance, and provide quality analysis. One of the most significant processes areas for the ACMM is Future Analysis Capabilities Development. It may not be feasible for an analysis organization to develop new capability when it is called upon to develop quantitative information; the decision horizon is often close. Consequently, the effective analysis organization must be proactive and seek to have the needed skills and tools at hand.[11]

Measurement and Analysis (2) Measurement and Analysis develops and sustains a measurement capability that is used to support management information needs.

SG 1 Align Measurement and Analysis Activities—Measurement objectives and activities are aligned with identified information needs and objectives.

    SP 1.1-1   Establish measurement objectives.
    SP 1.2-1   Specify measures.
    SP 1.3-1   Specify data collection and storage procedures.
    SP 1.4-1   Specify analysis procedures.

SG 2 Provide Measurement Results—Measurement results that address identified information needs and objectives are provided.

    SP 2.1-1   Collect measurement data.
    SP 2.2-1   Analyze measurement data.
    SP 2.3-1   Store data and results.
    SP 2.4-1   Communicate results.

Analysis Process and Analytic Product Quality Assurance (2) Analysis Process and Analytic Product Quality Assurance provide staff and management with objective insight into processes and associated work products.

SG 1 Objectively Evaluate Processes and Work Products—Adherence of the performed process and associated work products and services to applicable process descriptions, standards, and procedures is objectively evaluated.

    SP 1.1-1   Objectively evaluate analysis processes.
    SP 1.2-1   Objectively evaluate analytic work products and analysis services.

SG 2 Provide Objective Insight—Noncompliance issues are objectively tracked and communicated, and resolution is ensured.

    SP 2.1-1   Communicate and ensure noncompliance issues resolution.

SP 2.2-1   Establish records.

SG 3 Analysis Review

    SP 3.1-1   Perform an analysis independent review.

Configuration Management (2) Configuration Management establishes and maintains the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits.

SG 1 Establish Baselines—Identified work product baselines are established.

    SP 1.1-1   Identify configuration items.
    SP 1.2-1   Establish a configuration management system.
    SP 1.3-1   Create or release baselines.

SG 2 Track and Control Changes—Changes to the work products under configuration management are tracked and controlled.

    SP 2.1-1   Track change requests.
    SP 2.2-1   Control configuration items.

SG 3 Establish Integrity—Baseline integrity is established and maintained.

    SP 3.1-1   Establish configuration management records.
    SP 3.2-1   Perform configuration audits.

Establish and Maintain Analysis Capabilities (3) The purpose of Establish and Maintain Analyses Capabilities is to prepare for current analysis activities.

SG 1 Acquire Capabilities.

    SP 1.1-1   Accomplish changes made necessary by the study
    SP 1.2-1   Perform construct, acquire, or modify existing capabilities trades.
    SP 1.3-1   Construct or acquire capabilities.[*]

SG 2 Manage and develop analysts.

    SP 2.1-1   Identify unique skill requirements.
    SP 2.2-1   Establish leadership mechanisms.
    SP 2.3-1   Establish incentives for development.

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[*] Apply software acquisition CMM, perhaps.

SP 2.4-1   Establish mechanisms to balance team and home organization responsibilities.

SG 3 Establish and maintain mechanisms for analysis.

SP 3.1-1   Identify modeling, simulation, and data processing needs.
SP 3.2-1   Confirm analysis components readiness.

SG 4 Establish and maintain facilities for analysis.

SP 4.1-1   Establish the organization's shared vision.
SP 4.2-1   Establish an integrated work environment.

Future Analysis Capabilities Development (3) The purpose of Future Analysis Capabilities Development is to identify future analyses topic areas and to develop the future capabilities needed to perform those analyses.

SG 1 Develop Future Analysis Topic Areas.

SP 1.1-1   Collect stakeholder needs.
SP 1.2-1   Elicit additional stakeholder needs.
SP 1.3-1   Develop the customer issues.

SG 2 Develop Future Analysis Concepts and Mechanisms.

SP 2.1-1   Identify candidate future analysis concepts.
SP 2.2-1   Identify alternative mechanisms to accomplish future analysis concepts.
SP 2.3-1   Select concepts and mechanisms to perform future analyses.

SG 3 Develop Future Capability Requirements.

SP 3.1-1   Establish analysis scenarios.
SP 3.2-1   Establish a definition of required functionality.
SP 3.3-1   Develop requirements.
SP 3.4-1   Analyze requirements.
SP 3.5-1   Estimate future capability schedule and resources.
SP 3.6-1   Budget for future capabilities.

SG 4 Develop Future Analyses Plans.

SP 4.1-1   Plan for future analyses. The organization develops resource plans, analysis capability development projects, and basic background materials and technologies. (This facilitates rapid response when a specific issue or topic analysis question is posed.)
SP 4.2-1   Identify future decisions for quantitative analysis.

SP 4.3-1   Identify decision takers.
SP 4.4-1   Identify time analysis is needed.

Causal Analysis and Resolution (5) Causal Analysis and Resolution identifies causes of defects and other problems and takes action to prevent them from occurring in the future.

SG 1   Determine Causes of Defects.

SP 1.1-1   Select defect data for analysis.
SP 1.2-1   Analyze causes.

SG 2   Address Causes of Defects.

SP 2.1-1   Implement the action proposals.
SP 2.2-1   Evaluate the effect of changes.
SP 2.3-1   Record data.

5.3   Generic Goals and Practices

The generic goals and practices used in the ACMM are unmodified from those used in the SEI CMMI model and are presented here only for document completeness.

5.3.1   Generic Goals

General planning, control, implementation, and sustainment goals that apply to every process.

5.3.2   Common Features

Commitment To Perform: Creating policies and securing sponsorship

Ability To Perform: Establishing and maintaining plans, resources, assigned responsibility & authority, and training

Directing Implementation: Managing processes performance, product integrity, and stakeholder involvement

Verifying Implementation: Ensuring implementation and compliance

5.3.3   Generic Practices

Activities that ensure processes associated with analysis capabilities will be effective, repeatable, and lasting.

GG 1   Achieve Specific Goals—Transform identifiable input work products to produce identifiable output work products.

GP 1.1 Perform Base Practices to develop work products and provide services to achieve the specific goals.

GG 2   Institutionalize a Managed Process—Process is institutionalized as a managed process.

GP 2.1   Establish Organizational Policy for planning and maintaining the process.

GP 2.2   Establish and maintain the plan for performing the process.

GP 2.3   Provide adequate resources for performing the process, developing the work products, and providing the process services.

GP 2.4   Assign responsibility and authority for performing the process, developing the work products, and providing the process services.

GP 2.5   Train the people performing or supporting the process as needed.

GP 2.6   Manage designated process work products configuration.

GP 2.7   Identify and involve the relevant stakeholders as planned.

GP 2.8   Monitor and control the process against plans for performing the process and take appropriate corrective action.

GP 2.9   Objectively evaluate adherence of process against its process description, standards, and procedures, and address noncompliance.

GP 2.10   Review process activities, status, and results with higher-level management and resolve issues.

GG 3   Institutionalize a Defined Process—Process is institutionalized as a defined process.

GP 3.1 Establish and maintain the defined process description.

GP 3.2 Collect improvement information including work products, measures, measurement results, and information derived from planning and performing the process to support future use and the organization's processes and process assets improvement.

GG 4   Institutionalize a Quantitatively Managed Process—Process is institutionalized as a quantitatively managed process.

GP 4.1 Establish and maintain quantitative objectives for the capability that address quality and process performance based on customer needs.

GP 4.2 Stabilize the sub-process performance to determine the ability of the process to achieve the established quantitative quality and process-performance objectives.

GG 5 Institutionalize an Optimizing Process—Process is institutionalized as an optimizing process.

GP 5.1 Ensure continuous capability improvement in filling the organization's objectives.

GP 5.2 Identify and correct root causes of defects and other capability problems.

6. Analysis Capability Appraisal

Two types of appraisals can be conducted: a staged appraisal or a continuous appraisal. For a staged appraisal, each Specific Process and its associated Generic Practices are appraised at a given or greater level of maturity and the organization is appraised at the lowest maturity level attained for any Specific Practice. For a continuous appraisal, a maturity level is determined for each Specific Practice and its associated Generic Practice.[12,13]

An appraisal evaluates the analysis organization's capability for producing high-quality analysis products and services. Independent appraisals are taken seriously, even though they may report what the program staff already knows, because the appraisal team's messages often carry greater weight and reach higher levels in the organization. When a sponsor requests an appraisal, the time and expense will likely impact the participating organizations. Therefore, the team should plan to make efficient use of the participant's time as they may already be overworked, and the appraisal may be seen as an impediment to progress. Reviewing current analysis issues in the organization and its projected future analysis issues indicates analysis support needs.

The appraisal initially focuses on current analysis work and compares this work with the analysis needed to support the organization's mission. The appraisal examines the analysis processes that are used with an emphasis on initiation, planning, execution, timeliness, and quality assurance. It examines the tools, models, and simulations currently in use and determines their status with regard to verification (the tool meets its design), validation (the tool adequately represents the phenomena under study), and accreditation (there exists an authoritative statement of the tool's suitability to analyze specific issues). Of special interest for analysis tools is the appropriateness of the level of detail, the ease with which sensitivity analysis can be performed, and the experts' credentials used in analysis studies. The appraisal recommends changes to the processes being used, identifies tool shortfalls, and recommends development projects to close any analysis deficiencies.

6.1   Task Objective

To develop the approach and the methodology to be used by an appraisal team to conduct an independent, objective assessment of an organization's analysis capabilities utilizing the ACMM model.

6.2   Appraisal Purpose

The purpose of performing an independent appraisal of the state of analysis capability in an analysis or operations research organization is to enhance the organization's analysis processes. Documentation of both current analysis capabilities and future analysis needs to support the mission is required. To accomplish this, the current tools, models, and simulations must be examined and their use confirmed and corroborated. The result is a well-understood foundation (baseline) for a continuous process improvement to satisfy future needs with recommendations for specific, measurable improvements.

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6.3 Appraisal Approach

Access to information will come through a series of interviews with each group and through relevant documentation examination. The interviews will be used to identify analysis team leaders and sponsors; identify future analysis areas and topics; understand analysis processes, their use, and management; identify any process documents and capability descriptions; and identify accreditation documents along with the supporting verification and accreditation documentation for computer models and simulations in use. The approach includes:

- Examine the organization and evidential documentation of current analysis processes, tools, models and simulations, and related activities.

- Conduct interviews with selected members of the organization, including management, to identify both current and future analysis needs.

- Identify gaps in the existence and/or use of current processes, tools, and models and simulations, and future needs as a result of the independent team's appraisal of the organization's analysis capabilities.

- Make no quality judgments—only the processes existence and usage are evaluated.

- Make no attributions to specific organizations/programs or individual interviewees so that interviewees can be candid and forthcoming, without fear of reprisal.

- Results and recommendations are made available to management to be used, as they deem appropriate.

6.4 Analysis Appraisal and Processes Improvement

Figure 6.1 provides an overview of the process used for the analysis capability appraisal and for analysis product and analysis process improvement. These portray the high-level activities and flow of events that should occur when performing an appraisal and how these processes fit into process management and improvement activities. The following definitions are made to ensure that a distinction is made between the two processes.

Definitions:

Analysis Process: Process used by the organization to analyze decision questions and issues for the purpose of developing a supportable, quantitative basis for executive decisions.

Analysis Management Process: Methods by which the organization identifies issues and acquires capabilities (facilities, hardware/software, people skills, procedures, and data) to satisfy both current and future analysis needs.
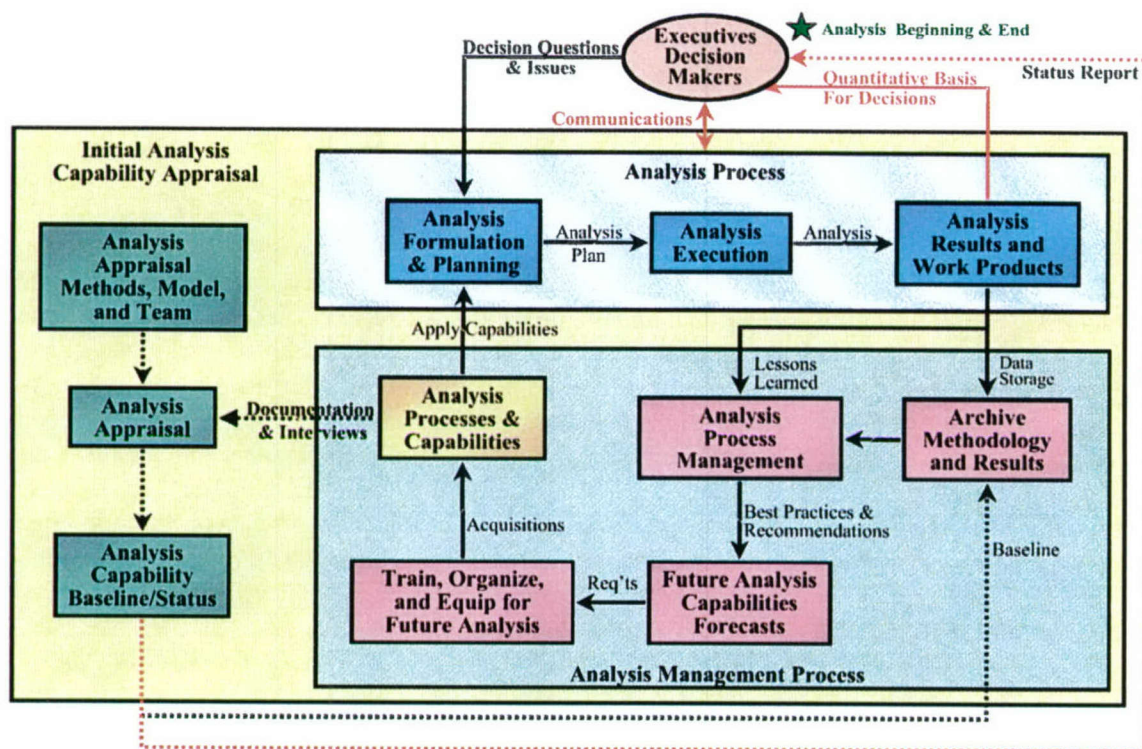
Figure 6.1. Analysis appraisal and process improvement.

6.5   Typical Independent Appraisal Outcomes

An independent appraisal provides an objective evaluation of an organization's analysis capabilities. This provides the basis for understanding both the current (baseline) capabilities and the future analysis process capability needs. Once this understanding is achieved, a plan of action can be generated and implemented to assure the organization will be able to provide quality analyses now and in the future. Specific appraisal outcomes might include:

- Common understanding of the analysis role in the organization

- Recommendations for monitoring, controlling, and reporting analyses within the organization and with the customer and relevant stakeholders

- Appraisal of the degree of analysis collaboration and coordination in use

- Recommended analysis processes, if needed

- Suggested products and/or process improvement opportunities

- Identification of potential problems

- Recommendations for management strategies

- Highlighting of successes and good practices

6.6   Independent Appraisal Team Role

The role that the appraisal team plays in the process is vital to the success of the appraisal. Objectivity of the team's appraisal is the only way to assure that the results are not biased or influenced by factors within the organization.

6.6.1   Team Structure

The team is structured to be independent and objective, thus providing no potential conflict of interest. Independent thinking can yield creative solutions and will be perceived as unbiased by interviewees. The team should be small enough to allow easy coordination and yet have enough members to assure coverage if some team members are not always available. There should always be at least two team members present during interviews. An open environment for information exchange allows leveraging existing staff knowledge and insight across all organization levels. The team members should bring a diversity of backgrounds (and opinions) that will help in achieving balanced decisions. Appraisal team members should be selected with regard to independence; that is, they should not be past or current members of the organization being assessed or any supporting or heritage organizations. A person with stature in the operations research/systems analysis community with the appropriate clearances should be selected to lead this effort. Experience conducting CMM appraisals is highly desirable.

6.6.2   Appraisal Team Activities

An independent appraisal is a complex and labor-intensive process. Adequate resources must be applied for the appraisal to be successful. The more comprehensive the up-front preparation is, the greater the chance for success with the available resources. The expertise and experience of the team leader and the dedication of the team members is vital to the appraisal's success. The team should be provided with unfettered access to key people and data to assure that the results are credible. Some typical appraisal team activities include the following:

- Select appraisal team leader. This is the responsibility of the sponsor.

- Select appraisal team members including group facilitators. Facilitators serve as the liaison to respective groups, identify interviewees, facilitate interviews, pursue and compile detailed group information (baseline descriptions) from the respective groups, and provide in-depth support to the appraisal team.

- Train the appraisal team. Training materials should include appraisal planning, analysis planning, and independent appraisal team lessons learned.

- Prepare, approve, and use the appraisal instrument (ACMM) as the appraisal basis.

- Identify internal team members from each of the organization's groups to act as liaisons.

- Meet with group facilitators to identify interview candidates.

- Participate with and support internal group interviews, and document review activities.

- Conduct organization management interviews; capture concerns and recommendations.

- Interview the analysis implementation staff and capture their concerns and recommendations.

- Obtain analysis work product samples. Access to organizations and people should be allowed with no restrictions.

- Evaluate analysis activities against the process model.

- Document the study results and recommendations.

- Prepare and present preliminary findings and recommendations.

- Prepare and deliver the final findings and recommendations report.

6.6.3   Interviews

The appraisal is conducted in a series of interviews, of two types. In the first type, the team conducts interviews with the organization's management with regard to forthcoming decisions and analysis support needs. Management should include the Director and his Deputy, the heads of each Group with their Deputies, and the principal staff positions of Chief Engineer and Lead Scientist. In the second type, the appraisal team conducts interviews with the government analysis team leaders and sponsors and examines documentation to discern the analysis processes actually being used in the organization. These interviews are modeled on the techniques used for CMMI appraisals. The team examines evidence of process execution without an evaluation of the process internals. These interviews are used to discover:

- An overview of analysis tasks that the interview candidate supports and their areas of responsibility

- Baseline information about the group organization and activities

- Organization charts, processes, capabilities and tools for analysis

- The consumers of the analysis results (internal and external)

- Governing requirements, policies, directives, etc., that might impact approaches and activities

- Summary and leading current group activity examples

- Schedules and definitions of future analysis applications

- Requirements for current and future analyses capabilities

- Known issues, shortfalls, or gaps

- Demonstrations, if available

- Areas and topics of future analyses

- Understanding of analysis process oversight by management

- Process documents and capability descriptions

- Accreditation documents along with the supporting Verification and Validation documentation for computer models and simulations in use

- The identity of the Government analysis team leaders and sponsors

In advance of the interviews, interview questions are developed that focus on these and other topics of interest. The topics covered in each interview are selected based on individual areas of responsibility and expertise. Interviews are based on a prepared interview questions list that is provided to the interviewees ahead of time. The list of questions is constructed to assure consistent key topics coverage and to provide a record of what was asked. Each interview session should have a designated recorder to capture impromptu and follow-on questions that were not scripted ahead of time.

At the end of the interview process, results are analyzed, and follow-up questions developed, if needed. There is no attribution of responses to interviewees or programs. Once all responses have been received and analyzed, the findings are documented, focused on each of the key interview topics. These findings are then briefed back to the interviewees to ensure that their responses are accurately stated.

6.6.4 Appraisal Report

The appraisal team's report to the sponsor should contain both findings and conclusions. The findings are facts and the conclusions are the team's judgments based on the facts. Recommendations should be prioritized both in terms of their urgency and their implementation feasibility. They should also be divided into near-term and longer-term recommendations. As much as possible, the report should have team consensus. However, differences of opinion can be documented. Recommendations should be clearly stated and should be specific enough to indicate what needs to be done. The report should contain only recommendations that are feasible to be implemented. If multiple organizations are being appraised, each recommendation should show organizational responsibilities for taking the action. There should be a limited number of recommendations (4 or 5) to bring the right level of focus (apply groupings, if necessary). The report should be presented to the group chiefs and then the sponsor. It may also be provided to other stakeholders who may be affected by the findings and recommendations if the sponsor requests this. The team should not present or give access to the report to any others without the appraisal sponsor's permission. For a possible follow-up, the team can consider proposing a re-visit at a later date to see what impact the recommendations have had and to suggest any course correction on the direction that resulted from the appraisal. It is not recommended that this team attempt any re-appraisal.

6.7 Evidentiary Artifacts to Corroborate Conformity to Model

Evidentiary artifacts may take form of hard or soft copy documentation, verbal corroboration from at least two sources, or other data as deemed appropriate by the independent appraisal team. This section delineates some typical work products from an analysis organization that provide evidence of the existence and use of standard processes that satisfy the ACMM. These artifacts are representative only and may vary widely depending on the organization's analysis requirements. These are defined at the Process Area Specific Goal level and include evidence from each of the specific practices.

Two evidentiary artifacts sources might include: an organizational measurement repository that contains or references actual measurement data and related information, or an organizational process asset library that contains information used to store and make available process assets containing documents, document fragments, and process implementation aids. This process-related documentation includes policies, defined processes, checklists, lessons-learned documents, templates, standards, procedures, plans, and training materials. Documents include both paper and electronic documents. (See the SEI CMMI specific practices for typical work products examples in related practices.)

The following items are examples of artifacts that were identified during a recent appraisal of an analysis organization using the ACMM:

- Tasking goals

- Regular resource meetings

- Analysis plans

- Master parameter datasheets

- Defined analysis execution for cyclical analyses

- Study result reviews

- Briefings or reports containing work products

- Peer reviews of models with cross-checking with other models

- Experienced team leaders judgment of SME qualifications

- Use of Master Schedule

- PMR to monitor contractor and FFRDC support

- Documentation of group staff meetings to monitor study status

- Stakeholder involvement in studies

- Risk identification during studies planning phase

- Inter-group chiefs one-on-one meeting minutes to ensure that analysis support meets current needs and anticipated future needs

- Reorganization establishes clearer roles and responsibilities within analysis organization

- Resource allocation tool identifies planned support level per task and to track planned staffing assignments

- Appraisal reviewed by intelligence community production centers

- Informal means to identify and control configuration items

- File structure for storing analysis reports on networks

- Flexibility to "reach back" for expertise

- Instances of project-level focus on process or product improvement

- Guidelines for conducting analyses

- Standard process for data calls to external groups to get correct data in the right format

- Use of Popkin's System Architect tool for architecture analysis

- Instances of new staff OJT

6.8 Potential Consequences of Not Meeting ACMM Goals

For each specific goal, the effect of the organization's processes not satisfying the ACMM's goals has consequences that may be far reaching. The potential impacts of these analysis shortfalls are listed below. The only real remedy is to develop processes to conform to the ACMM process areas.

Analysis/Problem Formulation Goals

- Analysis performed may fail to meet executive needs—wrong analysis executed.

- Analysis might be delayed while the analysis team struggles with formulating and bounding the problem—analysis may not be timely.

- Analysis may be more costly than necessary due to a premature analysis team commitment; that is, a false start that wastes resources.

- Analysis planning may be inconsistent with executive resource commitments.

- Analysis may require rework, with added costs and time—resources might be wasted.

Analysis and Data Planning

- Measures of Merit (MOM) to be computed may not be identified, the algorithms to be used may not be specified, and the data to be gathered may not be known, resulting in the wrong or incomplete data being gathered.

- The wrong data may be gathered

- Analysis might not be supported by certified data.

- The project may not finish before the resources are expended.

- Without commitments to plans, the plans may not be carried out.

Analysis Execution

- Analysis results may not be accepted.

- Quantitative results may not be generated.

- Incomplete or erroneous data may be gathered.

- Incomplete data may preclude the MOM calculation.

- MOM may not be computed correctly.

- Analysis may not be repeatable.

Analysis Resolution

- Decision maker may not understand the analysis and may make potentially wrong decisions or may fail to use the results in decision-making.

- Analysis may not be understood by stakeholders, which can result in confusion and analysis rejection.

- Analysis may not be appropriate for the problem formulated.

- The measures of merit may not be ranked in importance to the decision criteria with a potential to select an incorrect alternative.

- The decision may be more strongly influenced by things that cannot be measured. If the incommensurables and other factors are not addressed, a faulty decision might be made.

Analysis Reporting

- Documentation may be incomplete, which limits future use of results in addressing similar problems.

- Documentation may be incomplete, which causes reviewers to question conclusions.

- If adequate archives are not maintained, then there may be difficulty in answering future questions about this analysis

Work Product Confirmation

- Selecting the wrong work products for confirmation may result in incomplete or defective confirmation, which may result in defective analyses being published.

- Incomplete or defective peer reviews may cause defective work products to corrupt the analysis.

- Defects that are not discovered until analysis resolution may cause extensive rework.

- Work products may not meet analysis needs.

- Work products, especially models and simulations, may not perform as intended.

Model or Simulation Corroboration

- Improper models or simulations may not reflect the real world and lead to erroneous analysis results and executive decisions.

- Without corroboration, it may be difficult to accredit models and simulations.

- There is a potential that the analysis can be refuted or not accepted if there is a lack of confidence that the supporting models and simulations are correct

SME Qualification

- Lack of or poor SME selection criteria could lead to the selection of unqualified SMEs, which could mislead the analysis.

- Unqualified SMEs could lead to erroneous analysis results and bad decisions by executives.

- If the necessary qualifications for SME are not specified, the expert selected might lack the desired expertise.

- Analysis might not be repeatable if it is based on non-expert opinions.

Analysis Monitor and Control

- Failure to monitor with a resulting loss of control might result in wasted resources.

- Analysis may not be accomplished in time to effect a decision.

- Resources may be exhausted before the analysis is completed.

- Critical review and quality assurance steps may be sacrificed resulting in incomplete or flawed analysis.

Analysis Provider Agreement

- Analysis provider selection methods might lead to selecting the wrong provider who provides poor analysis products, resulting in bad executive decision making.

- Without proper control, an analysis provider might not stick to agreement and thereby fail to meet schedules and cause delays and the waste of resources.

External Stakeholder Involvement Management

- Lack of coordination might lead to duplication of effort or gaps in analysis coverage, resulting in wasted resources.

- Poor coordination might lead to a misunderstanding about analysis vision resulting in the wrong analysis.

- Poor communications might lead to frustration and poor performance by the integrated team.

- Necessary analysis data from external stakeholders may not be available.

Risk Management

- Unidentified risks could lead to rework.

- Unidentified risks might cause analysis failure.

- Unmitigated risks could result in surprises and unexpected problems with an adverse impact on analysis cost, schedule, and performance.

- An improperly structured risk management process might lack a disciplined environment for decision-making and the efficient use of program resources.

Internal Analysis Team Management

- Without a defined process application, the analysis might flounder.

- Excessive time could be spent to determine individual roles, responsibilities, and relationships.

- Lack of a shared vision for the analysis could mean that activities are uncoordinated.

- Individual activities products might not be capable of being integrated.

- Inappropriate assignments could result in inefficient or ineffective effort by team members.

Quantitative Analysis Management

- Analysis may not achieve objectives.

- Analysis may not meet the process-performance objectives.

- Management may not be aware of analysis progress and assets consumption.

- Problems with the analysis might not be identified in time to be corrected; e.g., variation may be outside the control bounds.

Organizational Process Focus

- The organization may develop inappropriate processes.

- Critical process areas may be neglected while non-critical processes are developed.

- Inadequate processes could be in use, which could result in inefficiencies and ineffective analysis.

- Workers could be frustrated with the lack of organizational processes.

- Process are not improved and opportunities missed.

Organizational Process Definition

- Process assets are not available to sustain the analysis.

- The organization could be unaware of process measures and data for planning and monitoring the analysis process, which might lead to schedule slippage and excessive assets consumption.

- Ad hoc and inconsistent processes could be employed, which might lead to inefficient and inconsistent performance .

Organizational Training

- Analysts may lack the skills and knowledge to execute analysis.

- Effective training might not be delivered, which could result in wasted resources.

- Training records may not be maintained, which could mean that job assignments are inappropriate.

Organizational Process Performance

- The organization may lack the data to manage the analysis process, which could mean that the analysis exceeds cost and the schedule slips.

- Lack of performance models may mean that desired performance can not be stated, which could mean flawed analysis planning.

Organizational Innovation and Development

- Quality objectives derived from the organization's business plan may not be achieved.

- Process-performance objectives derived from the organization's business plan may not be achieved.

- The organization's processes and technologies may not be measurably improved.

Measurement and Analysis

- Management may lack data to make informed decisions.

- Organization may not be able to objectively measure current activities.

- Organizational data may not be aligned with information needs and objective; i.e., the data gathered and maintained may not be useful.

Analysis Process and Product Quality Assurance

- Management and staff may lack objective insight into process and associated work product quality.

- Flawed analysis is published and presented to decision makers.

- Even good analysis may lack credibility.

- Incomplete or non-objective reviews may result in defective analysis being published.

Configuration Management

- There may be difficulty in Accreditation of Models and Simulations.

- Might result in unreliable analysis results.

- Some potential for unauthorized changes to work products (data, tools, results, reports, and briefings).

Establish and Maintain Analytic Capabilities

- It is possible that analytic capabilities will degrade.

- Trained analysts may not be available for future analysis.

- Models and Simulations may not be capable of Accreditation.

- Databases and data files may not be capable of Certification.

Develop Future Analysis Capabilities

- There is a possibility that the organization will spend limited resources on creating or improving capabilities for which there is little need.

- There is a possibility that the organization will lack the necessary capabilities to perform appropriate future analysis.

- There is a possibility that future analysis will be driven by stale capabilities vice decision maker needs.

Causal Analysis and Resolution

- Defects could be repeated in future work.

- Defect detection might be casually treated if defect causes are not analyzed and addressed.

6.9   Potential Benefits of Meeting ACMM Goals

If the ACMM goals are satisfied, there are potential benefits to the organization's process improvements and its ability to perform quality analyses, resulting in mission success for the analysis organization. Helping to establish and meet these goals is one of the main purposes of creating and using the ACMM.

A listing of some of the expected benefits of using this model include:

- A better understanding of the role that analysis plays in the organization's processes

- Appraisal of the degree of analysis collaboration and coordination within the organization

- Recommendations for monitoring, controlling, and reporting analyses

- Recommended analysis processes with criterion and documentation requirements, if needed

- Recommended process for future analyses development

- A current tool suite appraisal and its suitability for future analyses

- Independent support for analysis tool investment

- Following well-defined analysis processes improves customer satisfaction, resource efficiency, analysis quality and timeliness, results preservation, and support to decision makers.

- Managing, monitoring, and controlling analysis processes helps to ensure effective communication, helps studies utilize organizational resources appropriately, helps reduce task risks, and helps assure that objectives are met.

- Metrics, Quality Assurance, and Configuration Management help executives make informed decisions on activities and trends. They also provide visibility and feedback on the processes and work products and enable the storage and retrieval of analysis work products and final results.

- Clarifying the organization's mission roles and responsibilities helps ensure that it is well suited for satisfying the current and future customer analysis needs and to apply limited resources appropriately.

- Managing processes properly provides the means for consistently identifying and acting on improvement opportunities; enhance quality; and use training resources effectively.

- Proper analysis formulation can improve meeting customer expectations in a timely manner and prevent inefficient use of resources.

- Analysis planning helps ensure that analysis approach is properly defined to meet objectives, tools are correctly applied, and the appropriate data is utilized.

- Proper analysis execution and review increases the acceptability and analysis quality.

- Creating, reviewing, and archiving analysis documents captures the work performed by the organization, ensures it is accurately represented, and preserves it for future reference.

- Properly corroborated models and simulations can lead to higher quality analysis results and better support to decision makers.

- Utilizing appropriately qualified SME support can provide the organization with the expertise needed to produce high-quality results in support of decision makers.

- Analysis monitor and control helps ensure that analyses are accomplished as planned—in a timely manner—and resources are not wasted.

- External stakeholders involvement helps to ensure that analyses results are in keeping with external stakeholder expectations, limits duplication of efforts, and avoids gaps in analysis.

- Risk management processes help identify and mitigate issues early to minimize failures and avoid rework.

- Analysis process management improves the quality and study results effectiveness by leveraging from expertise across the organization.

- Collaboration and communications improve communications quality and clarifies roles and responsibilities.

- Established measurement objectives, metrics, and reporting capability helps measure current activities, track trends, project future needs, and make informed management decisions.

- Quality assurance supports the delivery of high-quality analysis by providing visibility and feedback on the processes and work products throughout the project life and across the organization.

- Configuration management enables analysis reports and supporting information storage and retrieval so that analysis integrity and history can be maintained, study approach and results reused, and models and simulation accredited.

- Establishing and maintaining analysis capabilities helps prevent staff analytic capabilities degradation and tools effectiveness.

- Identifying future analysis needs based on stakeholder and customer requirements helps to ensure that the organization is well suited to carry out the customer analysis needs and to spend limited resources efficiently.

Continuous analysis process improvement identifies opportunities to improve efficiency, enhance effectiveness, evolve best practices, fix inadequate processes, eliminate inappropriate processes,

reduce time spent on non-critical processes, make the entire organization and each individual an integral part of improvement operations, and improve analysis.

Establishing and maintaining useable and effective standard processes make process assets readily available to sustain analysis and control the use of inconsistent processes, which might lead to inefficient and inconsistent performance.

Developing staff skills and knowledge in key areas will enhance the analysis results quality, assure effective use of training resources, minimize ramp-up time for new staff, and avoid false starts due to lack of process awareness.

7. Recommendations

The ACMM is recommended to analysis organizations interested in improving the reliability and quality of their studies. It is also recommended to the purchasers of operations research and system analysis who are often asked to take the conclusions and recommendations of a study on faith alone.

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Appendix—Analysis CMM Graphics

The following charts provide a graphical representation of the ACMM process areas, specific goals, specific practices, and the CMMI generic goals and practices. These charts may aid in understanding the overall organization and structure of the model.

Analysis Capability Maturity Model (ACMM)

Reference Analysis Process

Quantitative Basis For Decisions

Establish & Maintain Analysis Capabilities

Consumer/Decision Makers

Communications

Decision Questions & Issues

Analysis Process

Analysis Formulation
1. Identify Issue
2. Identify Decision
3. Identify Stakeholders
4. Specify Level of Effort

Analysis Preparation
1. Develop Analysis Questions
2. Develop decision criteria
3. Identify incommensurables
4. Specify importance, ranking, of criteria
5. Develop measures
6. Bound the analysis
7. Develop alternatives
8. Develop ROMS of cost/ schedule
9. Review preparation with consumer

Analysis Planning
1. Develop & test algorithms to compute measures
2. Identify constraints
3. Estimate resources
4. Estimate schedule
5. Develop scenarios; alternate contexts for decisions
6. Test scenarios for sufficiency, detail, & issue illumination
7. Nominate data sources
8. Analysis Plan peer review
9. Review analysis planning with the consumer

Data Planning if Real World Data
1. Identify data sources
2. Plan for data collection
3. Develop sampling plan/ experiments design
4. Plan for data aggregation/ reduction
5. Plan for data certification
6. Estimate cost of data collection
7. Review cost & schedule with consumer

Data Planning if Expert Solicitation
1. Plan for data elicitation
2. Develop criteria for SMEs
3. Identify candidate SMEs
4. Evaluate candidate SME against criteria
5. Select SMEs
6. Estimate SME elicitation cost
7. Review cost & schedule with consumer

Data Planning if Model & Simulation
1. Develop selection criterion for M&S
2. Identify M&S alternatives
3. Select M&S
   If M&S development required
   a. Estimate development cost & schedule
   b. Review with appropriate stakeholders
   c. Modify existing M&S or create new
   d. Develop M&S
   e. Monitor development progress
4. Plan for accreditation of M&S
   a. Verification
   b. Validation
5. Design run plan (sensitivity)
6. Develop M&S execution cost & schedule
7. Review cost & schedule with consumer

Data Gathering
1. Data collection
2. Monitor & control data collection to assure adherence to plan
3. Certify data
4. Data delivery for analysis

Analysis Execution
1. Plot the data
2. Calculate measures

Analysis Resolution
1. Relate analysis to issues & questions
2. Relate measures to decision criteria
3. List incommensurables and other factors

Analysis Quality Assurance

Analysis Reporting
1. Final decision reporting
2. Lessons learned
3. Analysis details documentation
4. Analysis methods, data, & results archiving
   a. Taxonomy, data model, search to facilitate search

Analysis Appraisal Model Structure

The foundation for appraising analysis capabilities using a proven best practices approach

* Based on the Software Engineering Institute's Capability Maturity Model Integrated (CMMI) concepts - SE/SW/IPPD/SS, V1.1

Analysis Appraisal Instrument*

Analysis Sustainment Process Areas

Analytic Process Management Process Areas

Analysis Management Process Areas

Analysis Implementation Process Areas

Generic Goals

General planning, control, implementation, and sustainment goals which apply to every process.

Common Features

Commitment To Perform

Creating policies & securing sponsorship

Ability To Perform

Establishing and maintaining plans, resources, assigned responsibility & authority, and training

Directing Implementation

Managing processes performance, product integrity, & stakeholder involvement

Verifying Implementation

Ensuring implementation & compliance

Generic Practices

Activities that ensure processes associated with analysis capabilities will be effective, repeatable, and lasting.

Specific Goals

Specific goals unique to the process area that describes what must be implemented to satisfy the processes.

Specific Practices

Specific Practices

Specific Practices

Activities considered important in achieving specific goals.

Major building blocks in establishing organizational analysis capabilities.

Analysis Implementation Process Areas and Specific Goals

Analysis Implementation Process Areas

Related processes performed to achieve an appropriate, reliable, repeatable, and objective quantitative analysis

Models or Simulation Corroboration Process Area

Work Product Confirmation Process Area

Analysis Resolution Process Area

Analysis Reporting Process Area

Analysis Execution Process Area

Analysis & Data Planning Process Area

Analysis Formulation Process Area

Subject Matter Expert Qualification

Model or Simulation Corroboration Specific Goals:
1. Prepare for Corroboration
2. Corroborate the Models or Simulations

Subject Matter Expert Qualification
1. Develop SME Qualifications
2. Compare desired credentials and candidates to select SME

Analysis Resolution Specific Goals:
1. Interpret analysis work products
2. Identify significant factors outside the scope of the analysis

Work Product Confirmation Specific Goals:
1. Prepare for Confirmation
2. Perform Peer Reviews
3. Confirm Selected Work Products

Analysis Reporting Specific Goals:
1. Document analysis work products
2. Analysis Reporting
3. Analysis archiving

Analysis Execution Specific Goals:
1. Prepare for Analysis Execution
2. Data Gathering and Certification
3. Analyze Data Product Measures of Merit

Analysis & Data Planning Specific Goals:
1. Establish and maintain analysis planning estimates
2. Develop and maintain an Analysis Plan
3. Develop and maintain a Data Plan
4. Integrate the Plans
5. Establish and maintain commitments to the Plan

Analysis Formulation Specific Goals:
1. Manage analysis issues and identify inconsistencies with analysis products and decisions

Analysis Implementation Specific Practices

Analysis Formulation Specific Practices:

1.1-1 Obtain an understanding of analysis issues
1.2-1 Obtain an understanding of the decisions influenced by the analysis
1.3-1 Develop alternative decisions and the decision criteria
1.4-1 Obtain commitment to the issues to be analyzed
1.5-1 Manage changes in analysis issues
1.6-1 Maintain bi-directional traceability of issues and analysis products
1.7-1 Identify inconsistencies between analysis products and issues

Analysis Reporting Specific Practices:

1.1-1 Relate analysis to the issues and questions
1.2-1 Relate measures to the decision criteria

2.1-1 Report final analysis interpretation

3.2-1 Archive analysis methods, data, results, and lessons learned

Analysis & Data Planning Specific Practices:

1.1-1 Estimate analysis scope
1.2-1 Estimate analysis work products and task attributes
1.3-1 Define analysis life cycle
1.4-1 Determine estimates of effort and cost

2.1-1 Establish guidelines for analysis
2.2-1 Establish evaluation criteria
2.3-1 Select measure of merit
2.4-1 Identify and develop alternative analysis approaches & selection criteria
2.5-1 Evaluate alternative approaches
2.6-1 Select analysis approach
2.7-1 Develop detailed alternative solutions (decisions) and selection criteria
2.8-1 Evolve operational concepts and scenarios
2.9-1 Identify analysis risks
2.10-1 Plan for analysis resources
2.11-1 Establish the analysis plan
2.12-1 Determine data needs
2.13-1 Establish a technical data package

3.1-1 Plan for data management
3.2-1 Plan for data certification
3.3-1 Establish data descriptions
3.4-1 Analyze potential sources of data
3.5-1 Evaluate and determine sources of data
3.6-1 Perform make, acquire, or reuse data analyses
3.7-1 Establish the data plan

4.1-1 Integrate the analysis and data plans
4.2-1 Plan for needed knowledge and skills
4.3-1 Plan stakeholder involvement
4.4-1 Develop analysis and data support documentation
4.5-1 Establish the budget and schedule

5.1-1 Review plans that affect the analysis
5.2-1 Reconcile work and resource levels
5.3-1 Obtain plan commitment

Analysis Execution Specific Practices:

1.1-1 Review plans for completeness
1.2-1 Establish the analysis environment
1.3-1 Determine data gathering or generation sequence
1.4-1 Establish data formats and file structures

2.1-1 Collect the data using the data plan
2.2-1 Monitor selected data gathering processes
2.3-1 Evaluate selected data
2.4-1 Revise the data supplier agreement or relationships
2.5-1 Certify data

3.1-1 Confirm readiness of data components for aggregation
3.2-1 Aggregate data into measures of merit
3.3-1 Package analytic work products

Work Product Confirmation Specific Practices:

1.1-1 Select work products for confirmation
1.2-1 Establish the confirmation environment
1.3-1 Establish confirmation procedures and criteria

2.1-1 Prepare for peer reviews
2.2-1 Conduct peer reviews
2.3-1 Analyze peer review data

3.1-1 Perform confirmation
3.2-1 Analyze confirmation results and identify corrective actions

Analysis Implementation Specific Practices (cont)

**Analysis Resolution
Specific Practices:**

1.1-1 Relate analysis to the issues and questions
1.2-1 Relate measures to the decision criteria

2.1-1 List incommensurables and other factors

**Models or Simulation Corroboration
Specific Practices:**

1.1-1 Select model or simulation for corroboration
1.2-1 Select features of the model or simulation for
corroboration
1.3-1 Identify the real-world data to be used for comparison
1.4-1 Establish the corroboration environment
1.5-1 Establish corroboration procedures and criteria

2.1-1 Generate model or simulation, synthetic data for
corroboration
2.2-1 Compare synthetic data to the real-world data
2.3-1 Analyze the agreement between the synthetic and real-
world data sets

**Subject Matter Expert Qualification
Specific Practices:**

1.1-1 Select Analysis issue for SME
1.2-1 Identify knowledge or expertise needed
for the analysis issue
1.3-1 Establish desired credentials for the
SME

2.1-1 Generate pool of prospective SME
candidates
2.2-1 Elicit credentials of SME candidates
2.3-1 Compare credentials of the SME
candidates with the desired credentials
2.4-1 Select SME from the candidates pool

Analysis Management Process Areas and Specific Goals

Related processes to manage analysis

Analysis Management Process Areas

Quantitative Analysis Management Process Area

Specific Goals:
1. Quantitatively manage the analysis
2. Statistically manage sub-process performance

Management of Internal Analysis Team Process Area

Specific Goals:
1. Use the analysis defined process
2. Establish Team Composition
3. Govern Team Operations

Risk Management Process Area

Specific Goals:
1. Prepare for risk management
2. Identify & analyze risks relative importance
3. Mitigate risks

Management of External Stakeholders Involvement Process Area

Specific Goals:
1. Coordinate & collaborate with relevant stakeholders
2. Develop the analysis's shared vision for management of external stakeholders involvement
3. Organize integrated teams for analysis

Analysis Provider Agreement Process Area

Specific Goals:
1. Establish and maintain supplier agreements
2. Satisfy supplier agreements

Analysis Monitor and Control Process Area

Specific Goals:
1. Monitor actual analysis performance & progress against the analysis plan
2. Manage corrective action to closure when performance or results deviate from plan
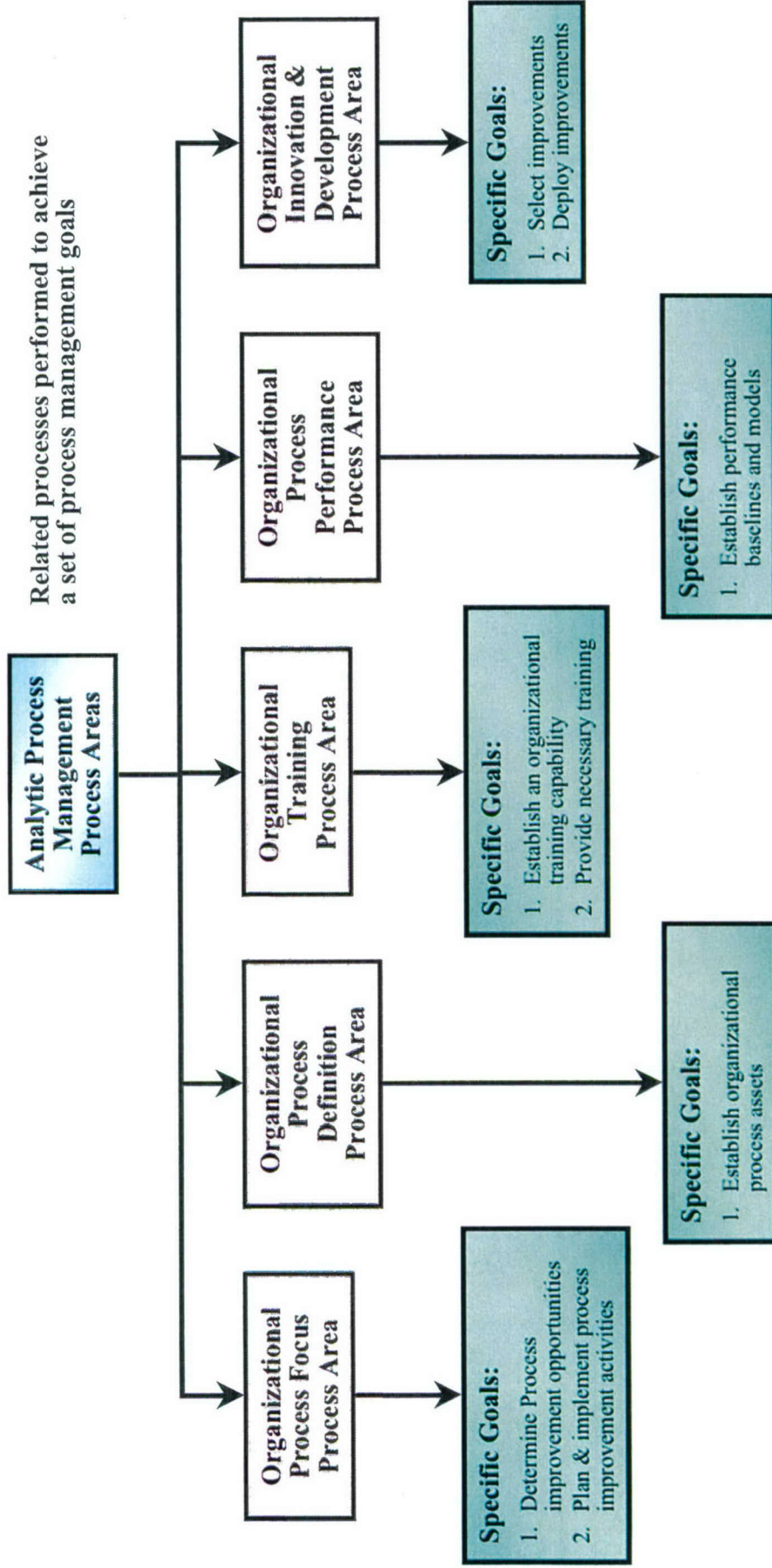
Analysis Management Specific Practices

Analysis Monitor & Control Specific Practices:

1.1-1 Monitor analysis planning parameters
1.2-1 Monitor commitments
1.3-1 Monitor risks
1.4-1 Monitor data management
1.5-1 Monitor stakeholder involvement
1.6-1 Conduct progress reviews
1.7-1 Conduct milestone reviews

2.1-1 Analyze issues
2.2-1 Take corrective actions
2.3-1 Manage corrective actions

Analysis Provider Agreement Specific Practices:

1.1-1 Specify analysis to be provided
1.2-1 Determine potential providers
1.3-1 Select providers
1.4-1 Establish provider agreements

2.1-1 Review products
2.2-1 Execute provider agreement
2.3-1 Accept provider product
2.4-1 Transition products

Risk Management Specific Practices:

1.1-1 Determine risk sources & categories
1.2-1 Define risk parameters
1.3-1 Establish risk management strategy

2.1-1 Identify risks
2.2-1 Evaluate, categorize, & prioritize risks

3.1-1 Develop risk mitigation plans
3.2-1 Implement risk mitigation plans

Quantitative Analysis Management Specific Practices:

1.1-1 Establish the analysis's objectives
1.2-1 Compose the defined process
1.3-1 Select the sub-processes that will be statistically managed
1.4-1 Manage analysis performance

2.1-1 Select measures and analytic techniques
2.2-1 Apply statistical methods to understand variation
2.3-1 Monitor performance of selected sub0processes
2.4-1 Record statistical management data

Management of External Stakeholders Specific Practices:

1.1-1 Manage stakeholder involvement
1.2-1 Manage dependencies
1.3-1 Resolve coordination issues

2.1-1 Define analysis shared vision context
2.2-1 Establish analysis shared vision

3.1-1 Determine integrated team structure for analysis
3.2-1 Develop analysis activities preliminary distribution to external stakeholders
3.3-1 Identify external stakeholder data sources
3.4-1 Establish integrated teams

Management of Internal Analysis Team Specific Practices:

1.1-1 Establish defined process
1.2-1 Use organizational process assets for planning
1.3-1 Integrate plans
1.4-1 Manage analysis using plans
1.5-1 Contribute to organizations process assets

2.1-1 Identify team tasks
2.2-1 Identify needed knowledge and skills
2.3-1 Assign appropriate team members

3.1-1 Establish a shared vision
3.2-1 Establish team charter
3.3-1 Define roles and responsibilities
3.4-1 Establish operating procedures
3.5-1 Collaborate among interfacing teams

Analytic Process Management Process Areas and Specific Goals

Related processes performed to achieve a set of process management goals

Analytic Process Management Process Areas

Organizational Process Focus Process Area

Specific Goals:
1. Determine Process improvement opportunities
2. Plan & implement process improvement activities

Organizational Process Definition Process Area

Specific Goals:
1. Establish organizational process assets

Organizational Training Process Area

Specific Goals:
1. Establish an organizational training capability
2. Provide necessary training

Organizational Process Performance Process Area

Specific Goals:
1. Establish performance baselines and models

Organizational Innovation & Development Process Area

Specific Goals:
1. Select improvements
2. Deploy improvements

Analytic Process Management Specific Practices

Organizational Process Focus Specific Practices:

1.1-1 Establish organizational process needs
1.2-1 Appraise the organization's processes
1.3-1 Identify the organization's process improvements

2.1-1 Establish process action plans
2.2-1 Implement process action plans
2.3-1 Deploy organizational process assets
2.4-1 Incorporate process-related experiences into the organizational process assets
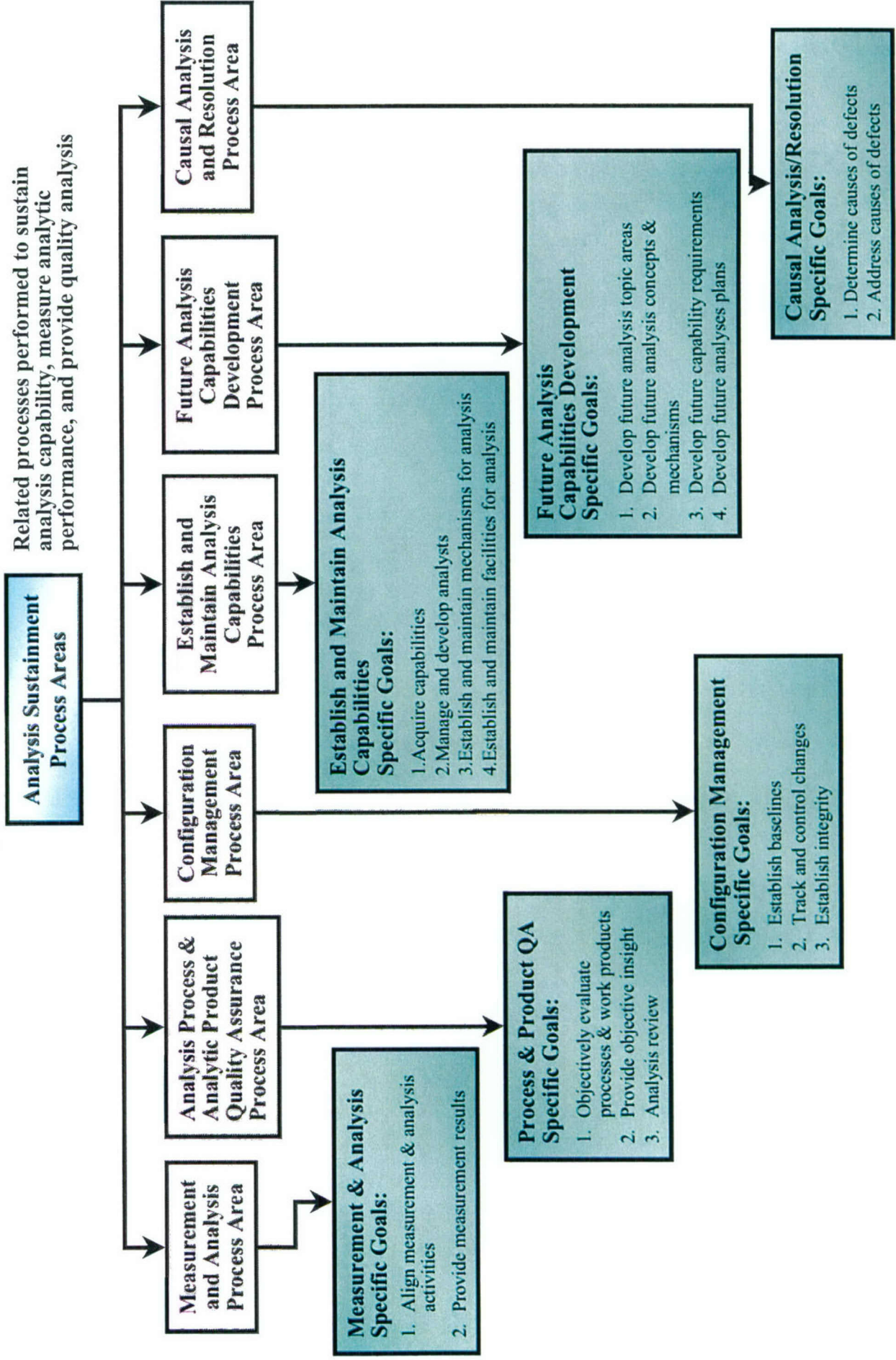
Organizational Process Definition Specific Practices:

1.1-1 Establish standard processes
1.2-1 Establish life-cycle model descriptions
1.3-1 Establish tailoring criteria and guidelines
1.4-1 Establish the organization's measurement repository
1.5-1 Establish the organization's process asset library

Organizational Training Specific Practices:

1.1-1 Establish strategic training needs
1.2-1 Determine which training needs are the responsibility of the organization
1.3-1 Establish an organizational training tactical plan
1.4-1 Establish training capability

2.1-1 Deliver training
2.2-1 Establish training records
2.3-1 Assess training effectiveness

Organizational Innovation & Development Specific Practices:

1.1-1 Collect and analyze improvement proposals
1.2-1 Identify and analyze innovations
1.3-1 Pilot improvements
1.4-1 Select improvements for deployment

2.1-1 Plan the deployment
2.2-1 Manage the deployment
2.3-1 Measure improvement effects

Organizational Process Performance Specific Practices:

1.1-1 Select processes
1.2-1 Establish process performance measures
1.3-1 Establish quality and process performance objectives
1.4-1 Establish process performance baselines
1.5-1 Establish process performance models

Analysis Sustainment Process Areas and Specific Goals

Related processes performed to sustain analysis capability, measure analytic performance, and provide quality analysis

Analysis Sustainment Process Areas

Causal Analysis and Resolution Process Area

Future Analysis Capabilities Development Process Area

Establish and Maintain Analysis Capabilities Process Area

Configuration Management Process Area

Analysis Process & Analytic Product Quality Assurance Process Area

Measurement and Analysis Process Area

Causal Analysis/Resolution Specific Goals:

1. Determine causes of defects
2. Address causes of defects

Future Analysis Capabilities Development Specific Goals:

1. Develop future analysis topic areas
2. Develop future analysis concepts & mechanisms
3. Develop future capability requirements
4. Develop future analyses plans

Establish and Maintain Analysis Capabilities Specific Goals:

1. Acquire capabilities
2. Manage and develop analysts
3. Establish and maintain mechanisms for analysis
4. Establish and maintain facilities for analysis

Configuration Management Specific Goals:

1. Establish baselines
2. Track and control changes
3. Establish integrity

Process & Product QA Specific Goals:

1. Objectively evaluate processes & work products
2. Provide objective insight
3. Analysis review

Measurement & Analysis Specific Goals:

1. Align measurement & analysis activities
2. Provide measurement results

Analysis Sustainment Specific Practices

Configuration Management
Specific Practices:

1.1-1 Identify configuration items
1.2-1 Establish configuration management system
1.3-1 Create or release baselines

2.1-1 Track change requests
2.2-1 Control configuration items

3.1-1 Establish configuration management records
3.2-1 Perform configuration audits

Causal Analysis & Resolution
Specific Practices:

1.1-1 Select defect data for analysis
1.2-1 Analyze defects

2.1-1 Implement the action proposals
2.2-1 Evaluate the effect of changes
2.3-1 Record data

Analysis Process & Analytic Product Quality Assurance
Specific Practices:

1.1-1 Objectively evaluate processes
1.2-1 Objectively evaluate work products and sources

2.1-1 Communicate and ensure resolution of non-compliance issues
2.2-1 Establish records

3.1-1 Perform an independent review of the analysis

Future Analysis Capabilities Development
Specific Practices:

1.1-1 Collect stakeholder needs
1.2-1 Elicit needs
1.3-1 Develop the customer issues

2.1-1 Identify candidate future analysis concepts
2.2-1 Identify alternative mechanisms to perform future analyses
2.3-1 Select concepts and mechanisms to perform future analyses

3.1-1 Establish analysis scenarios
3.2-1 Establish a definition of required functionality
3.3-1 Develop requirements
3.4-1 Analyze requirements
3.5-1 Estimate future capability schedule and resources
3.6-1 Budget for future capabilities

4.1-1 Plan for future analyses
4.2-1 Identify future decisions for quantitative analysis
4.3-1 Identify decision takers
4.4-1 Identify time analysis is needed

Measurement & Analysis
Specific Practices:

1.1-1 Establish measurement objectives
1.2-1 Specify Measures
1.3-1 Specify data collection & storage procedures
1.4-1 Specify analysis procedures

2.1-1 Collect measurement data
2.2-1 Analyze measurement data
2.3-1 Store data and results
2.4-1 Communicate results

Establish and Maintain Analysis Capabilities
Specific Practices:

1.1-1 Accomplish study necessary changes
1.2-1 Perform construct, acquire, or modify existing capabilities trades
1.3-1 Construct or acquire capabilities

2.1-1 Identify unique skill requirements
2.2-1 Establish leadership mechanisms
2.3-1 Establish incentives for development
2.4-1 Establish mechanisms to balance team and home organization responsibilities

3.1-1 Identify modeling, simulation, and data processing needs
3.2-1 Confirm readiness of analysis components

4.1-1 Establish the organization's shared vision
4.2-1 Establish an integrated work environment

Generic Goals and Practices

Generic Goals

Generic Practices

- Perform Base Practices to develop work products and provide services to achieve the specific goals

1. Achieve Specific Goals

Transform identifiable input work products to produce identifiable output work products

2. Institutionalize a Managed Process

Process is institutionalized as a managed process

- Establish Organizational Policy for planning and maintaining the process.
- Establish and maintain the plan for performing the process.
- Provide adequate resources for performing the process, developing the work products, and providing the process services.
- Assign responsibility and authority for performing the process, developing the work products, and providing the process services.
- Train the people performing or supporting the process as needed.
- Manage designated process work products configuration.
- Identify and involved the relevant stakeholders as planned.
- Monitor and control the process against plans for performing the process and take appropriate corrective action.
- Objectively evaluate adherence of process against its process description, standards, and procedures, and address noncompliance.
- Review process activities, status, and results with higher level management and resolve issues.

3. Institutionalize a Defined Process

Process is institutionalized as a defined process

4. Institutionalize a Quantitatively Managed Process

Process is institutionalized as a quantitatively managed process

- Establish and maintain the defined process description.
- Collect improvement information including work products, measures, measurement results, and information derived from planning and performing the process to support future use and the organization's processes and process assets improvement.

5. Institutionalize an Optimizing Process

Process is institutionalized as an optimizing process

- Establish and maintain quantitative objectives for the capability that address quality and process performance based on customer needs.
- Stabilize the sub-process performance to determine the ability of the process to achieve the established quantitative quality and process-performance objectives.

- Ensure continuous capability improvement in filling the organization's objectives.
- Identify and correct root causes of defects and other capability problems.